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LABORATORY STUDIES OF TERMITE RESISTANCE V. THE TERMITE RESISTANCE OF PLASTICS

F. J. Gay, et al

Commonwealth Scientific and Industrial Research Organization, Australia

1969

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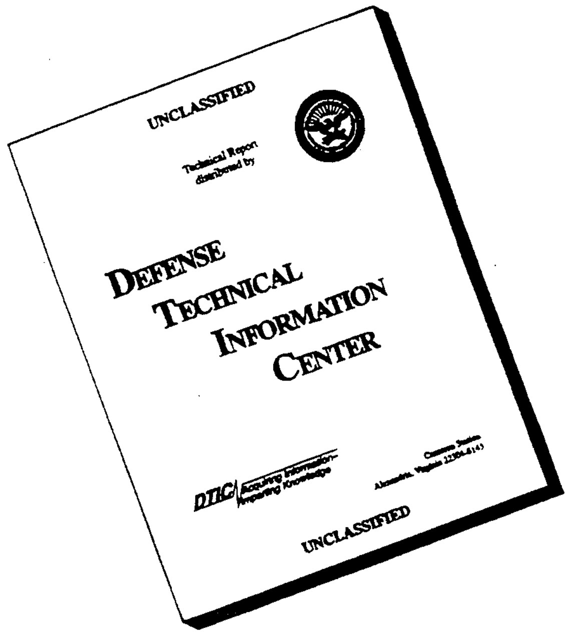

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V. The Termite Resistance of Plastics

F. J. GAY and A. H. WETHERLY

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Commonwealth Scientific and Industrial
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FOREWORD

The first edition of this publication, which appeared in 1962, contained the first comprehensive account of laboratory tests to evaluate the termite resistance of plastics. It attracted considerable attention not only from manufacturers, suppliers, and consumers of plastic products in Australia but also from many overseas countries, and as a result it has been out of print for some time.

Since the first edition, laboratory studies of the termite resistance of plastics have continued, and again an appreciable volume of useful information, which could be of value to manufacturers and consumers of plastics, has been accumulated.

It was felt, therefore, that the most satisfactory and economical solution would be to bring together in a single publication all the laboratory studies on the termite resistance of plastics that have been carried out by this Division. In doing this, virtually all of the first edition has been incorporated in the present paper, with only minor amendments where necessary. This approach eliminates both the need for continual cross-references to the earlier paper and the problem of locating a copy when specific details are required.

LABORATORY STUDIES OF TERMITE RESISTANCE

V. THE TERMITE RESISTANCE OF PLASTICS

By F. J. Gay* and A. H. Wetherly*

[*Manuscript received March 14, 1969*]

Summary

An account is given of a series of laboratory tests to determine (i) the resistance to termite attack of various plastics, (ii) the factors affecting such resistance, and (iii) methods of improving resistance of those plastics shown to be susceptible to attack.

The plastics in common use vary widely in susceptibility to attack and range from highly resistant materials such as nylon, phenolic laminates, and epoxy and polyester resins to readily damaged materials such as plasticized polyvinyl chloride, low-density polyethylene, and cellulose esters.

The nature of the surface finish is unimportant in relation to termite attack. An increase in thickness of plastic films or foils has been shown to reduce the susceptibility to attack but the reason is not evident. In some materials hardness appears to be important. This has been observed in studies with materials such as polyvinyl chloride or cellulose acetate with different amounts of plasticizer, and also in polyethylenes of different density. Polyethylene also shows increasing termite resistance as molecular weight increases and melt flow index decreases.

There are indications that susceptibility is also influenced by the choice of plasticizer as polyvinyl chloride plasticized with tricresyl phosphate is significantly less susceptible than when plasticized with dioctyl phthalate.

The amount of attack on susceptible plastics may be reduced by the addition of small quantities of any of several insecticides, of which the best appear to be aldrin and dieldrin. Possible hazards involved in the widespread use of plastics with such additions require further investigation. A significant reduction in damage to susceptible plastics materials has been achieved by the addition of a small volume of a non-toxic mineral filler such as hard silica or zircon flour, but practical application is limited by processing difficulties.

The relevance of results of laboratory tests of plastics to their performance in service, and the applicability of these results in Australia, are discussed.

I. Introduction

The increasing use of plastics for a wide variety of purposes has meant that in certain applications these materials are exposed to termite hazard. This is particularly true for plastic piping used for agricultural purposes and plastic-sheathed cables used for telephone or electrical supply. It is natural, therefore, that there should be considerable interest in the resistance to termite attack of plastics generally used for these and similar purposes, and it was to provide information on this that the present investigations were begun. Subsequently, the scope of the study was broadened to include a wider range of plastics and to investigate the effects of variations in manufacturing formulations and/or the addition of insecticidal materials during processing on the termite resistance of plastics.

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Published information on the subject, although now assuming moderate proportions, is sometimes contradictory. This may be due to different species of termites being involved, or to variations in the type and formulation of a particular plastic investigated by different workers.

Wolcott (1946) records undiluted (unplasticized) cellulose acetate as being readily eaten by *Cryptotermes brevis*. He also found that the same species will eventually penetrate a film of 5% polymerized methyl methacrylate but is apparently unable to penetrate a film containing 20% solids of polymerized vinylidene chloride or one of polyvinyl acetate containing 55% total solids. Snyder (1955) found cellulose acetate was the only plastic of those he tested that was not attacked by termites. The test insects were species of *Coptotermes*, *Heterotermes*, and *Reticulitermes*. He also refers to termite attack on polyvinyl chloride coatings on underground cables and to termite penetration of both Neoprene and natural rubber insulations. A recent personal communication from Dr. Snyder refers to tests by the United States Department of Agriculture in which the following plastics were shown to be susceptible to termite attack: polyethylene, polyvinyl chloride, Neoprene, butyl rubber, and natural rubber. The least susceptible material was polyvinyl chloride, and thickness was considered to be an important factor in relation to susceptibility—the thicker the material, the lower the susceptibility. Additional tests showed that the incorporation of small amounts of cyclodienes, e.g. dieldrin, was effective in preventing attack. Colwill (1958) refers to tests in Nigeria in which nylon monofilaments were damaged by termites, and also notes the commercial use of metallic naphthenates for termite-proofing dielectrics such as polyvinyl chloride and polyethylene. He states that untreated dielectrics vary in their resistance to termite attack, and that those containing chlorine, e.g. polyvinyl chloride, seem relatively immune compared with non-chlorine compounds such as polyethylene. With polyethylene, the amount of damage appeared to depend on density, low-density polyethylene probably being more easily attacked than a high-density type.

Tests carried out by the Department of Forestry, Pretoria, South Africa, (Dr. P. D. M. Krogh, personal communication) showed that cable sheaths consisting of either polyethylene containing 10% polyisobutylene or polyethylene containing 10% butyl rubber were severely damaged, probably by *Macrotermes natalensis*. The inclusion of chemicals such as metallic naphthenates or pentachlorphenol during manufacture has not proved effective, possibly because of destruction or decomposition during the high-temperature extrusion of the polythene sheath.

The Southern African Section of the Plastics Institute, London, (Mr. J. N. Ratcliffe, personal communication) reports that sections of black and white polyethylene water pipe remained sound after 4½ years' exposure to high termite hazard in South Africa, whereas small-bore polyvinyl chloride piping was punctured by termites within 3 years. Reports of termite attack on telephone cables in the Central African Federation are conflicting, one report stating that polyethylene is attacked and polyvinyl chloride is not, and another the exact opposite. One of these reports claims that colour is important, black cable being least liable to attack and red cable most attractive.

The records of the Termite Research Unit, London, (kindly made available by Dr. W. V. Harris) include the following references to termite attack on plastics: (i) polyvinyl chloride strip used for wrapping electric cables in East Africa was severely

attacked in 17 months by species of *Odontotermes*; (ii) rubber-insulated polychloroprene-sheathed cable shorted after 4 months' use in Macao owing to termite attack; (iii) railway signal cable sheathed with Neoprene rubber, buried in the soil in Southern Rhodesia, was severely attacked after 6 weeks, but polyvinyl-chloride-coated cable buried in the same area was reported sound after a year, the termites responsible being *Macrotermes* or *Odontotermes*; (iv) plastic paint based on polyvinyl acetate was eaten by termites (probably *Microcerotermes diversus*) in Baghdad in 1956. Methods of protecting plastics against termite attack are reported to include the use of dieldrin in polyvinyl chloride and a mixture of aldrin and dieldrin in polyethylene. In a published account of termites in Europe, Harris (1962) refers to laboratory tests with the endemic species, *Reticulitermes lucifugus*, in which polyethylene sheeting and polyurethane foam were readily attacked.

Rychtera and Bartakova (1963) summarized data on termite attack on plastics from a wide variety of sources, and classified the various plastics as follows:

Resistant.—Epoxides, unplasticized polyvinyl chloride, polymethyl methacrylate, polyvinyl carbazole, phenol–melamine–aniline–formaldehydes.

Slightly attacked.—Polychlorotrifluoroethylene, polytetrafluoroethylene.

Markedly attacked.—Polyethylene, nylon, plasticized polyvinyl chloride, polyvinyl butyral, polypropylene.

Becker (1963, 1964) gives details of laboratory tests in which 50 plastics of different types were exposed to five species of termites belonging to five different genera. He found that (i) phenoplasts and aminoplasts are termite-resistant if they are hard enough and do not contain susceptible fillers, (ii) polyester, polyamide, polymethyl methacrylate, and epoxy resins are resistant, (iii) polyethylene, polystyrene, and polyvinyl chloride with a low plasticizer content are to a great extent resistant, and (iv) polyurethane, soft polyethylene, and plasticized polyvinyl chloride are susceptible. He considers that hardness of the material is of vital importance and that surface finish also affects practical performance.

Colwill (1964), in a report of the results of a world-wide questionnaire on pest damage to transmission lines and cables, refers to numerous instances of termite damage to polyethylene- and polyvinyl-chloride-sheathed and insulated cables. He also draws attention to the performance of a nylon-sheathed polyethylene-insulated cable in Malaya which suffered only one localized area of damage during 3 years' exposure to termites.

Pacitti (1965) surveyed the literature relating to termite attack on plastics and rubbers. He concludes that polymeric materials show considerable variation in their resistance to termite attack, and that this is due to physical factors such as hardness rather than to chemical composition.

In Australia there have been abundant instances of termite attack on plastics in service. Government departments, such as Postmaster-General's, Works, Supply, and Civil Aviation, have reported termite damage to plastic-sheathed and insulated communications and power cables, and manufacturers and their agents have reported many cases of attack on plastic piping used for irrigation, stock watering, or domestic water supplies. The plastics involved have been polyvinyl chloride, polyethylene, and

cellulose acetate butyrate, and where specific identifications have been made the termites responsible were *Coptotermes acinaciformis* or *Mastotermes darwiniensis*. These attacks have been observed in all mainland States, although almost all damage to plastic piping has been confined to the low-rainfall areas of the southern and south-western portions of the continent.

It is clear from the above summary that termite attack on plastics is quite widespread and that a number of different genera are capable of causing economic damage. No single plastic has yet proved completely resistant against a range of termites, and the commonest approach to proofing such materials is the incorporation of insecticidal compounds during processing.

The investigations reported here have been carried out over several years. Initially, test samples were obtained by canvassing Australian manufacturers and suppliers of plastic piping and cable sheathings and consisted mainly of representative material from normal production runs. In addition, however, occasional experimental batches were prepared for testing, usually to assess the value of insecticidal additives.

In 1958, a conference of representatives of the Plastics Institute of Australia, the Commonwealth Departments of Civil Aviation, Supply, and Works, and the CSIRO Division of Entomology was convened to consider the problem of termite attack on plastics and to plan research programmes. As a result, testing since that date has been increasingly concerned with experimental material specially formulated to check particular points.

II. Material and Methods

Almost all tests have been made using the standard laboratory colony technique developed in this Division (Gay *et al.* 1955), and employing *Nasutitermes exitiosus* (Hill), *Coptotermes lacteus* (Frogg.), and, to a lesser extent, *Coptotermes acinaciformis* (Frogg.). A limited number of tests was made with *Mastotermes darwiniensis* Frogg., in which samples of plastics were exposed to a large colony of several thousand individuals maintained in a metal tank in the laboratory.

The choice of test species of termites is governed by their economic significance, availability, and amenability to laboratory maintenance. In temperate Australia most termite damage is caused by *Coptotermes* spp. (mainly *C. acinaciformis* and *C. frenchi*) and *Nasutitermes exitiosus*, and in tropical Australia by *Mastotermes darwiniensis* and *Coptotermes acinaciformis*. Of these, only *M. darwiniensis* cannot be maintained satisfactorily in the small experimental groups necessary for an extensive laboratory testing programme, so tests with this species have necessarily been restricted to the type referred to above.

The more extensive use made of *C. lacteus* as a test insect compared to its more aggressive and voracious congener, *C. acinaciformis*, is based firstly on the convenience of being able to collect populous field colonies of the former species readily in areas where colonies of the economic species *N. exitiosus* are also common. Secondly, the Australian species of *Coptotermes* form a closely knit group with similar food preferences and susceptibilities to toxicants. For this reason *C. lacteus*, although never considered of economic significance throughout its restricted range of distribution in south-eastern Australia, is a useful guide to the performance of the economically important *C. acinaciformis*.

Test specimens consisted of short lengths (normally 3–3½ in.) of plastic pipe, plastic-sheathed cable, or plastic sheet (½-in.-wide strips). When plastic film was tested it was either wrapped around blocks of susceptible timber (3½ by ½ by ½ in.), or rolled into hollow cylinders (½-in. diameter) and fastened with metal clips, or used as a sheet barrier (flat or folded) between an experimental group of termites without food and an adjacent food source (Fig. 1).

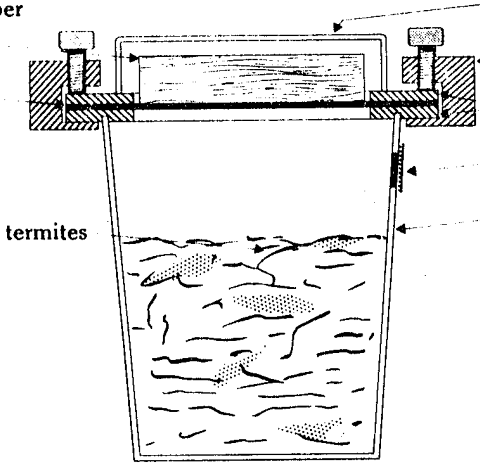


Fig. 1.—The experimental unit used for many of the tests of plastic films.

In the earlier tests in this investigation, the sheet, cable, or pipe samples were used without any special preparation after cutting to size, i.e. the cable and pipe samples had exposed ends and the sheet material exposed edges. It soon became obvious that termite attack generally started from the ends or edges of samples where presumably the termites could readily obtain purchase with their mandibles. In order to ensure the most rigorous test of a candidate plastic, it was necessary to mask the cut ends and edges of samples so that the termites were presented with only a flat or curved surface of plastic. This masking was done in a variety of ways: with sealing wax, epoxy resins, or metal edging or capping, and in the tabulated results given later such samples are referred to as having "capped ends" or "masked edges". Normally, four test samples were exposed in each standard colony, but with piping only a single sample was included. All materials were tested in duplicate colonies against each species of termite and the attack on test samples was recorded as both an actual and a percentage weight loss. The figures for these losses, given in Tables 1–7, represent the means of duplicate readings in each instance. In addition, visual assessments of the extent and nature of damage were made for most materials, using the following system:

Slightly attacked.—Penetration from the edge of the sample not exceeding 10% of the width of the sample, or excavation on the face of the sample not exceeding 10% of the thickness.

Attacked.—Penetration from the edge of the sample more than 10% but not exceeding 33% of the width, or excavation on the face of the sample more than 10% but not exceeding 33% of the thickness.

Badly attacked.—Edge penetration more than 33% but less than 66% of the width, or surface excavation greater than 33% but not exceeding 66% of the thickness.

Destroyed.—Edge penetration more than 66% of the width of the sample, or surface excavation exceeding 66% of the thickness.

III. Results and Comments

(*a*) *General Survey*

The results may be considered most conveniently in separate groups, each of which represents a separate phase of the investigation. The first group concerns the plastics in most general use in Australia. These plastics, obtained from a variety of sources, were tested without any concern regarding their formulation or the nature of the sample, i.e. piping, sheet, or cable sheathing, in order to make a general survey of the termite susceptibility of plastics. It was felt that this information could serve as a useful guide to the most satisfactory utilization of plastics in situations where termite hazard exists. The results of this general survey are summarized in Table 1, from which the following conclusions may be drawn.

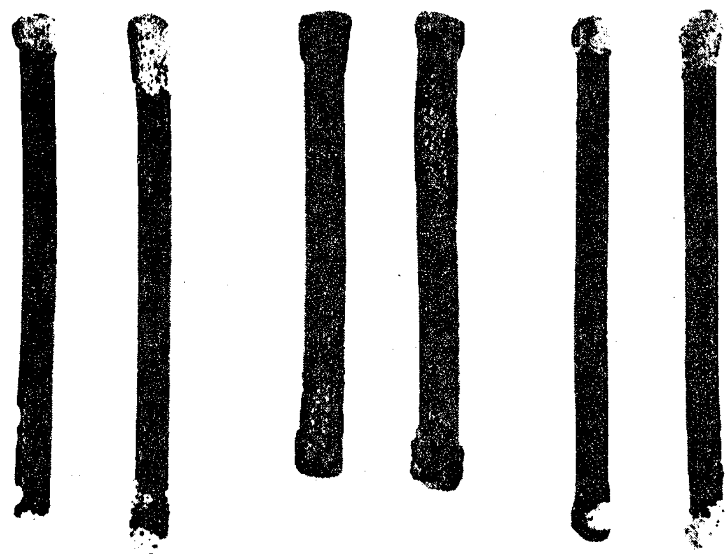
Susceptibility to termite attack varies considerably among the plastics in widespread use, ranging from virtually complete immunity to a high level of susceptibility. Polyvinyl chloride, in the semi-rigid or rigid conditions, either as sheeting or piping, is virtually unattacked, but when plasticized for use as cable sheathing or insulant or as tape, is very susceptible to attack (Fig. 2). Polyethylene, in low-density grades used for piping or cable sheathing, is readily attacked (Fig. 3), but the more recently developed high-density grades show a high resistance to termite damage. The epoxy and acetal resins tested are either highly resistant or immune to attack. Polyester resins also appear to be immune, and the small weight losses detected in these samples are considered to be due to causes other than termite attack. Cellulose acetate butyrate, both in sheet form and in piping, is readily attacked (Fig. 3). Natural rubber is slightly susceptible. All of the synthetic elastomers show some susceptibility to attack (especially Thiokol). The phenolic laminates examined are either highly resistant or immune. All grades of nylon tested are highly resistant and show no more than slight nibbling; this also occurs with polytetrafluorethane. Makrolon (a polycarbonic acid ester of 4,4′-dihydroxydiphenyl-2,2-propane) is immune to attack, as is high-impact polystyrene. Kralastic (a copolymer of styrene–butadiene–acrylonitrile) is susceptible to attack; polypropylene is slightly susceptible; polyvinylidene chloride (as film), polyurethane (as film), and polyisobutylene are very susceptible to attack. All the foamed or expanded plastics tested (polyvinyl chloride, polyurethane, polystyrene) are very susceptible to attack.

(*b*) *Effect of Plasticizers*

The marked difference in performance of plasticized and unplasticized polyvinyl chloride, as indicated in Table 1, led to an investigation of the effects of variations in

the level and nature of plasticizer on the termite resistance of the resultant product. Five tests were made using polyvinyl chloride sheet and one test with cellulose acetate butyrate rod. The results are summarized in Table 2.

It will be seen that in Test No. 1 unplasticized polyvinyl chloride was unattacked, but any of the plasticizer treatments resulted in some degree of termite attack. A statistical analysis of these results shows that all treatments are significantly different from each other. It may be concluded, therefore, that the addition of tricresyl phosphate to polyvinyl chloride makes it less susceptible to termites than if a similar quantity of dioctyl phthalate is added.



(a) (b) (c)

Fig. 2.—Various types of polyvinyl-chloride-sheathed cables after exposure to attack by *Coptotermes acinaciformis* in laboratory colonies. (*a*) Non-migratory PVC sheath; (*b*) Arctic PVC sheath; (*c*) general-purpose PVC sheath.

In Test No. 2 (Table 2) polyvinyl chloride plasticized with tricresyl phosphate is obviously much less susceptible to attack than when plasticized with an equal quantity of either dioctyl phthalate or di-isooctyl phthalate. This confirms the findings of the previous test; but such a result could be attributed simply to hardness, as the material plasticized with tricresyl phosphate has a British Standard hardness of 96 compared with a hardness of 90 for the material plasticized with either of the other two compounds.

This point was checked in Test No. 3 (Table 2) in which the levels of the two plasticizers were adjusted to give products of approximately the same hardness.

It is clear from these results that a reduction in the amount of either plasticizer (with an accompanying increase in hardness) produces a significant reduction in susceptibility to termite attack. Statistical analysis also indicates that polyvinyl chloride plasticized with tricresyl phosphate is significantly less susceptible than when

TABLE 1

LABORATORY TESTS OF RESISTANCE OF VARIOUS PLASTICS AND RELATED MATERIALS TO ATTACK OF FOUR SPECIES OF TERMITES

N.e., *Nasutitermes exitiosus*; *C.l.*, *Coptotermes lacteus*; *C.a.*, *Coptotermes acinaciformis*; *M.d.*, *Mastotermes darwiniensis*

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Remarks
		Polyethylene				
1	Sheet (Grade 7 Alkathene), 0·125 in. thick	8, Exposed edges	*N.e.*	0·22	2·1	Two samples slightly attacked, extensive nibbles on edges of 8
		8, Exposed edges	*C.l.*	0·80	8·1	Two samples badly attacked, 6 slightly attacked to attacked
	Sheet (Grade 20 Alkathene), 0·125 in. thick	8, Exposed edges	*N.e.*	0·24	2·1	Three samples slightly attacked, extensive nibbles on edges of 8
		8, Exposed edges	*C.l.*	0·79	7·5	Two samples badly attacked, 6 slightly attacked to attacked
2	Alkathene WJG-11 with 0·1% Nonox CI (anti-oxidant), 0·5 in. sheet	8, Exposed edges	*N.e.*	0·02	0·05	Five samples with few nibbles on edges
		8, Exposed edges	*C.l.*	0·08	0·20	All samples with nibbles on edges and faces
	As above + 0·1% Nonox WSF (anti-oxidant), 0·5 in. sheet	8, Exposed edges	*N.e.*	0·04	0·08	Seven samples with few nibbles on edges
		8, Exposed edges	*C.l.*	0·08	0·20	All samples with nibbles on edges and faces
	As above + 0·1% Santanox (anti-oxidant), 0·5 in. sheet	8, Exposed edges	*N.e.*	0·02	0·05	Seven samples with few nibbles on edges
		8, Exposed edges	*C.l.*	0·09	0·20	All samples with nibbles on edges and faces
3	Sheet (0·5 in. thick, high density: Hostalen GM 5010)	6, Exposed edges	*N.e.*	0·04	0·10	Few nibbles on 1 sample only
		6, Exposed edges	*C.l.*	0·13	0·35	Slight attack on edges of all samples
		6, Exposed edges	*C.a.*	0·15	0·40	Slight attack on edges of all samples
4	Sheet 0·0625 in. thick. Ethylene–butylene copolymer, based on 0·95 density polymer of melt flow index 0·4 (Grex 50C 4PG)	8, Strips	*N.e.*	0·064	0·95	Slight attack on 6 samples, nibbles on 2
		8, Strips	*C.l.*	0·038	0·57	Slight attack on 1 sample, nibbles on 7
		8, Strips	*C.a.*	0·157	2·30	Slight attack to attack on 4 samples, nibbles on 4
	Sheet 0·0625 in. thick. Ethylene–butylene copolymer based on 0·95 density polymer of melt flow index 0·3 (Rigidex special pipe compound)	8, Strips	*N.e.*	0·034	0·49	Slight attack on 3 samples, nibbles on 5
		8, Strips	*C.l.*	0·033	0·48	Slight attack on 2 samples, nibbles on 6
		8, Strips	*C.a.*	0·151	2·15	Slight attack on 6 samples, nibbles on 2
	Sheet 0·0625 in. thick. Ethylene–butylene copolymer, based on 0·96 density polymer, melt flow index 0·3, containing 2% carbon black (Rigidex pipe grade)	8, Exposed edges	*N.e.*	0·010	0·24	Nibbles on edges of all samples
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	0·102	2·60	Attack on 1 sample, slight attack on 6, nibbles on 1
		8, Masked edges	*C.l.*	0·010	0·30	Nibbles on faces and edges of 5 samples
5	Film (Visqueen), 0·003-in. thickness	1, Flat	*N.e.*	†	†	Termites in contact with film, no visible damage
		1, Folded	*N.e.*	†	†	Three penetrations of film (2 on fold, 1 on flat)
		1, Flat	*C.l.*	†	†	Termites in contact with film, no visible damage
		1, Folded	*C.l.*	†	†	One penetration of film on fold
		1, Flat	*C.a.*	†	†	Termites in contact with film, no visible damage
		1, Folded	*C.a.*	†	†	Five penetrations of film on fold
6	Film, grade 7F (0·002 in. thick)	8, Film wrapped around timber samples	*N.e.*	*	*	20–80% of film destroyed
			C.l.	*	*	About 10% of film destroyed
7	Cable (Grade 7 polythene)	8, Ends masked with sealing wax	*N.e.*	0·05	0·2	No visible attack, weight loss due to partial loss of wax seals from samples
		8, As above	*C.l.*	0·10	0·53	Extensive surface attack on 7 samples

		8, As above	*C.a.*	0·60	1·50	Conductor exposed in 7 samples
	Cable (Grade 20 polythene)	8, Ends masked with sealing wax	*N.e.*	0·02	0·1	No visible attack, weight loss due to partial loss of wax seals from samples
		8, As above	*C.l.*	0·01	0·04	Localized areas of slight attack on 5 samples
		8, As above	*C.a.*	0·69	3·11	Conductor exposed in all 8 samples
	Cable (87·5% Grade 20 polythene – 12·5% polyisobutylene)	8, Ends masked with sealing wax	*N.e.*	0·04	0·06	No visible attack, weight loss due to partial loss of wax seals from samples
		8, As above	*C.l.*	0·04	0·06	Small areas of slight attack on 4 samples
		8, As above	*C.a.*	1·94	4·15	Conductor exposed in 7 samples
8	Cable, sheathed with high-density polyethylene (density = 0·96 g ml)	8, Uncapped	*N.e.*	0·023	0·70	Nibbles on ends of sheath and core insulant
		8, Capped	*N.e.*	*	*	No visible attack
		8, Uncapped	*C.l.*	0·078	0·50	Surface nibbles on ends of sheath and core insulant
		8, Capped	*C.l.*	*	*	No visible attack
		8, Uncapped	*C.a.*	0·275	1·97	Attack on ends of all 8 samples
		8, Capped	*C.a.*	0·029	0·21	Slight attack on walls of 2 samples, nibbles on 3 more
	Cable, insulated with grade 03C polythene, with single overlapping of 0·004 in. brass tape with 20% overlap and outer sheath of 0·040 in. clear, low grade polythene	8, Uncapped	*N.e.*	0·033	0·40	Nibbles on ends and outer wall of cable sheath
		8, Capped	*N.e.*	*	*	No visible attack
		8, Uncapped	*C.l.*	0·031	0·09	Nibbles on ends of sheath
		8, Capped	*C.l.*	0·027	0·07	Patches of nibbles on surface of outer sheathing
		8, Uncapped	*C.a.*	0·090	0·52	Attack on ends of 3 samples, nibbles on walls of 1
		8, Capped	*C.a.*	0·027	0·15	Slight attack on walls of 3 samples, nibbles on 1
9	Polythene-sheathed cable, PVC insulation + glass tape barrier (0·375 in. diam.)	8, Wax-sealed ends	*N.e.*	*	*	No visible attack
		8, As above	*C.a.*	*	*	Small isolated patches of surface roughening
10	Piping (natural Alkathene), 0·5 in. I.D.	2, Plugged ends	*N.e.*	*	*	No visible attack
		2, Plugged ends	*C.l.*	*	*	Slight surface nibbling on samples
		4, Plugged ends	*C.a.*	0·5	0·3	Penetration through wall of 2 samples
	Piping (Alkathene pigmented with 2% titanium dioxide), 0·5 in. I.D.	2, Plugged ends	*N.e.*	*	*	No visible attack
		2, Plugged ends	*C.l.*	*	*	Slight surface nibbling on samples
		4, Plugged ends	*C.a.*	0·68	1·4	Extensive nibbling, penetration of wall of 1 sample
11	Pipe (DuPont extruded)	2, Uncapped	*N.e.*	0·053	0·50	Slight attack on ends of samples, extensive nibbles on walls
		2, Capped	*N.e.*	0·003	0·02	Extensive nibbling on walls of samples
		2, Uncapped	*C.l.*	0·006	0·05	Nibbles on ends of samples
		2, Capped	*C.l.*	*	*	No visible attack
		2, Uncapped	*C.a.*	0·025	0·23	Slight attack on ends of samples
		2, Capped	*C.a.*	*	*	No visible attack
		1, Uncapped	*M.d.*	0·09	0·08	Nibbles on ends of samples
12	High-density piping (1 in. I.D., 0·094 in. wall thickness)	2, Uncapped ends	*N.e.*	0·02	0·07	Nibbles on ends of samples
		2, Uncapped ends	*C.l.*	0·01	0·06	Nibbles on ends of samples
	Low-density piping. Sample 1 (1 in. I.D., 0·094 in. wall thickness)	2, Uncapped ends	*N.e.*	0·08	0·31	Extensive nibbles to slight attack on ends of samples
		2, Uncapped ends	*C.l.*	*	*	Nibbles on ends of samples
	Sample 2 (1 in. I.D., 0·094 in. wall thickness)	2, Uncapped ends	*N.e.*	0·04	0·18	Nibbles on ends of samples
		2, Uncapped ends	*C.l.*	0·02	0·09	Nibbles on ends of samples

TABLE 1 (*Continued*)

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. (g)	Eaten (%)	Remarks
		Polyethylene (Continued)				
13	Piping, extra high density and tensile strength (1 in. I.D., 0·0625 in. wall thickness)	2, Uncapped ends	*N.e.*	*	*	No visible attack
		2, Uncapped ends	*C.l.*	0·04	0·28	Extensive nibbling on ends of samples
		Polyvinyl Chloride				
14	Rigid sheet based on Corvic H.55/34 (0·0625 in. thick)	8, Exposed edges	*N.e.*	*	*	Traces of nibbles only on edges of some samples
		8, Exposed edges	*C.l.*	*	*	Traces of nibbles only on edges of some samples
	Semi-rigid sheet, based on Breon 202 with D.O.P. and dicyclohexyl phthalate plasticizer (0·0625 in. thick)	8, Exposed edges	*N.e.*	*	*	Traces of nibbles only, heavier than above
		8, Exposed edges	*C.l.*	*	*	Traces of nibbles only, heavier than above
15	PVC, unplasticized, impact-resistant with a percentage of chlorinated polyolefine (Hostalit Z, grey and yellow)	8, Sheet 0·094 in. thick	*N.e.*	0·024	0·16	Nibbling along edges of samples
		2, Uncapped, pipe 0·194 in. wall	*C.l.*	*	*	No visible attack
		2, Uncapped, pipe 0·194 in. wall	*C.a.*	*	*	Few nibbles on ends of samples
		8, Sheet, 0·094 in. thick	*C.a.*	*	*	Nibbles on all samples, slight attack on 1
16	Electrical tape, D.O.P.–T.C.P. plasticized (0·006 in. thick)	8, Tape wrapped around timber samples	*N.e.*	*	*	Approximately 25% of tape destroyed
			C.l.	*	*	Approximately 10% of tape destroyed
17	Film (Novon 700 series 18–20% plasticizer) 0·015 in. thick	2, Flat film	*N.e.*	†	†	Termites in contact with film, no visible attack
		2, Flat film	*C.l.*	†	†	Termites in contact with film, no visible attack
		2, Flat film	*C.a.*	†	†	Termites in contact with film, no visible attack
18	Foam, rigid expanded, 0·5 in. sheet	8, Strips	*N.e.*	0·242	9·75	All samples attacked, deeply channelled
		8, Strips	*C.l.*	0·075	3·07	All samples attacked
		8, Strips	*C.a.*	*	*	All samples attacked
19	Cable (non-migratory PVC sheath)	8, Ends masked with sealing wax	*N.e.*	0·14	0·38	No visible attack, weight loss due to partial loss of wax seals from samples
		8, As above	*C.l.*	0·59	1·52	Conductor exposed in 6 samples
		8, As above	*C.a.*	1·06	2·95	Conductor exposed in all 8 samples
	Cable (Arctic PVC sheath)	8, Ends masked with sealing wax	*N.e.*	0·86	1·18	No visible attack, weight loss due to partial loss of wax seals from samples
		8, As above	*C.l.*	1·00	1·41	Conductor exposed in 4 samples
		8, As above	*C.a.*	1·79	3·02	Conductor exposed in all 8 samples
	Cable (general purpose PVC sheath)	8, Ends masked with sealing wax	*N.e.*	0·21	0·62	No visible attack, weight loss due to partial loss of wax seals from samples
		8, As above	*C.l.*	0·37	1·07	Conductor exposed in 7 samples
		8, As above	*C.a.*	0·89	3·60	All samples badly attacked but conductor not exposed

	Cable (general purpose PVC insulant)	8, Ends masked with sealing wax	*N.e.*	0·01	0·05	No visible attack, weight loss due to partial loss of wax seals from samples
		8, As above	*C.l.*	0·13	0·63	Five samples badly attacked at ends
20	Cable (7/·052) Sample 1 (0·25 in. diam.)	8, Wax-sealed ends	*N.e.*	*	*	No visible attack
		8, As above	*C.l.*	‡	‡	No visible attack
	Sample 2 (0·25 in. diam.)	8, Wax-sealed ends	*N.e.*	0·28	0·66	Five samples with conductor exposed
		8, As above	*C.l.*	0·17	0·39	Five samples with conductor exposed
21	PVC insulated wire, glass tape barrier, PVC sheath (0·375 in. diam.)	8, Wax-sealed ends	*N.e.*	0·08	0·2	Sheath penetrated on 1 sample
		8, As above	*C.a.*	0·13	0·3	Sheath attacked in 5 samples
22	Cable, insulated with black PVC, no sheath, 7/064	8, Uncapped	*N.e.*	0·065	0·11	Slight attack on ends of 3 samples, nibbles on another 4
		8, Capped	*N.e.*	0·075	0·13	Slight attack on ends of 3 samples, mainly on Araldite seals
		8, Uncapped	*C.l.*	0·025	0·05	Nibbles on ends of 6 samples
		8, Capped	*C.l.*	0·089	0·16	Slight attack on end of 1 sample, several Araldite seals attacked
		8, Uncapped	*C.a.*	0·067	0·12	Attack on end of 1 sample, slight attack on ends of 4, nibbles on 1
		8, Capped	*C.a.*	0·064	0·12	Conductor exposed in 1 sample, attack mainly on Araldite seals
	Cable, insulated with black PVC, with PVC sheath, 7/·064	8, Uncapped	*N.e.*	0·223	0·27	Slight attack on ends of 3 samples, nibbles on another 3
		8, Capped	*N.e.*	0·160	0·21	Slight attack on walls of 2 samples, attack on another 1
		8, Uncapped	*C.l.*	0·370	0·50	Slight attack to attack on all 8 samples, conductor exposed in 1
		8, Capped	*C.l.*	0·281	0·35	Slight attack on walls of 6 samples, nibbles on 2
		8, Uncapped	*C.a.*	0·540	0·75	Nine penetrations of sheath, exposing conductor
		8, Capped	*C.a.*	0·420	0·52	Seven penetrations of sheath, exposing conductor
23	Semi-rigid PVC extruded over a steel core (Mipolam)	8, Strips	*N.e.*	0·077	0·45	Samples showing nibbles to slight attack
		8, Strips	*C.l.*	0·075	0·45	Samples showing nibbles to slight attack
		8, Strips	*C.a.*	0·358	2·25	Samples showing slight attack to attack
24	0·032 in. diam. wire, coated with PVC (Hostalit Z870/70) to overall diam. of 0·077 in.	12, Uncapped	*N.e.*	*	*	No visible attack
		12, Capped	*N.e.*	*	*	No visible attack
		12, Uncapped	*C.l.*	*	*	No visible attack
		12, Capped	*C.l.*	*	*	No visible attack
		12, Uncapped	*C.a.*	0·037	0·45	One sample destroyed (conductor exposed), others showing nibbles or slight attack
		12, Capped	*C.a.*	0·033	0·4	One-quarter of samples showing nibbles or slight attack
		3, Uncapped	*M.d.*	†	†	Samples slightly attacked to attacked
		3, Capped	*M.d.*	†	†	Samples slightly attacked to destroyed (conductor exposed)
25	Rigid piping, 0·75 in. I.D.	2, Ends plugged with rigid PVC	*N.e.*	*	*	No visible attack
		2, As above	*C.l.*	*	*	No visible attack
		4, As above	*C.a.*	‡	‡	No visible attack

TABLE 1 (*Continued*)

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Remarks
		Polypropylene				
26	Sheet (0·5 in. thick. mixture of grades MS and AS)	6, Exposed edges	*N.e.*	*	*	Traces of nibbles only
		6, Exposed edges	*C.l.*	0·21	0·56	Areas of slight attack on all edges
		6, Exposed edges	*C.a.*	0·85	2·25	Extensive areas of slight attack on all edges
27	Sheet (0·0625 in. thick, Grade GPE 33)	8, Exposed edges	*N.e.*	0·002	0·03	Edge nibbles on all samples
		8, Exposed edges	*N.e.*	0·003	0·09	Nibbles on 1 sample only
		8, Exposed edges	*C.l.*	0·008	0·12	Nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·007	0·14	Nibbles on edges of all samples
		8, Exposed edges	*C.a.*	0·036	0·60	Extensive nibbles on edges of all samples
	Sheet (0·0625 in. thick, Grade HPE 35)	8, Exposed edges	*N.e.*	0·003	0·05	Edge nibbles on all samples
		8, Exposed edges	*C.l.*	0·006	0·10	Nibbles on edges of all samples
		8, Exposed edges	*C.a.*	0·035	0·60	Extensive nibbles on edges of all samples
28	Cable. Black polypropylene-covered 7 ·044, with hard drawn copper conductor, nominal radial thickness of 0·030 in. polypropylene cover	8, Uncapped	*N.e.*	0·002	0·007	Nibbles on end of 1 sample
		8, Uncapped	*C.l.*	0·025	0·10	Nibbles on ends of all samples
		8, Uncapped	*C.a.*	0·025	0·09	Slight attack on end of 1 sample, nibbles on 5 others
	Cable. Polypropylene-sheathed	8, Uncapped	*N.e.*	0·039	1·0	Attack on insulant and sheath at one end
		8, Capped	*N.e.*	*	*	No visible attack
		8, Uncapped	*C.l.*	0·050	0·35	Nibbles on ends of sheath and on core insulant
		8, Capped	*C.l.*	0·020	0·125	Nibbles on walls of 2 samples
		8, Uncapped	*C.a.*	0·310	2·1	Extensive attack on ends of 5 samples; nibbles on 3 more
		8, Capped	*C.a.*	0·061	0·45	Shallow areas of attack on walls of 3 samples
29	Piping (1 in. I.D., 0·0625 in. wall thickness: Garnite)	2, Uncapped ends	*N.e.*	*	*	No visible attack
		2, Uncapped ends	*C.l.*	0·01	0·07	Extensive nibbles on ends of samples
		2, Uncapped ends	*C.a.*	0·10	0·7	Slight attack to attack on ends of samples
		Polystyrene				
30	Polystyrene–butadiene alloy (high impact. 0·125 in. sheet)	8, Exposed edges	*N.e.*	‡	‡	No visible attack
		8, Exposed edges	*C.l.*	*	*	No visible attack
31	Expanded polystyrene (Polyzote)	8, Exposed edges	*N.e.*	0·09	4·2	
		8, Exposed edges	*C.l.*	0·21	10·8	
		Polyurethane				
32	Elastomer, for pipe sealing (with silica filler), 0·5 in. sheet	8, Strips	*N.e.*	0·303	0·45	Shallow patches of nibbles on all samples
		8, Strips	*C.l.*	0·984	1·40	Hole through 1 sample, patches of nibbles on remainder
		8, Strips	*C.a.*	1·085	1·40	Holes through 7 samples, nibbles on 1
33	Cable sheathing (Estane 58016, cured cross-linked, containing 10% carbon black, 1% barium stearate)	8, Uncapped	*C.l.*	0·016	0·06	Nibbles on ends, 3 patches on walls
		8, Capped	*C.l.*	0·013	0·04	Several small patches of nibbles on walls
		8, Uncapped	*C.a.*	0·001	0·01	Four areas of nibbles, 1 of slight attack on ends and walls
		8, Capped	*C.a.*	0·040	0·15	Several patches of slight attack on walls

34	Polyester-prepolymer based foam. 2–3 lb cu ft density. 0·5 in. thick sheet	8, Strips	*N.e.*	0·105	4·75	
		8, Strips	*C.l.*	0·350	16·55	
	Polyether-prepolymer based foam. 2–3 lb cu ft density. 0·5 in. thick sheet	8, Strips	*N.e.*	0·117	7·35	
		8, Strips	*C.l.*	0·463	20·40	
35	Foam sheet 0·5 in. thick (Esta-foam)	8, Exposed edges	*N.e.*	0·43	15·2	All samples attacked
		8, Exposed edges	*C.l.*	0·66	21·8	All samples attacked
36	Lacquer film. 2 coats on susceptible timber	8, Exposed edges	*N.e.*	+	+	Two samples slightly attacked through film
		8, Exposed edges	*C.l.*	+	+	All samples badly attacked through film
		1, Exposed edges	*M.d.*	+	+	Sample badly attacked through film
		Nylon				
37	Nylon 6.6 (DuPont grade FM10.001). sheet 0·094 in. thick	8, Exposed edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	0·04	0·2	Slight roughening of edges of samples
38	Nylon 6 (Grilon). 0·5 in. sheet	8, Exposed edges	*N.e.*	*	*	Isolated small patches of nibbles on edges of samples
		8, Exposed edges	*C.l.*	*	*	Traces of nibbles on edges of samples
		8, Exposed edges	*C.a.*	*	*	Extensive nibbles on edges of samples
39	Akulon polyamide. 0·125 in. sheet	8, Exposed edges	*N.e.*	*	*	Scattered patches of nibbles on edges of some samples
		8, Exposed edges	*C.l.*	*	*	Small patches of nibbles on edges of all samples
40	Nylon 6.6 (A100 E Black 937). 0·125 in. sheet	8, Exposed edges	*N.e.*	*	*	Isolated small patches of nibbles on edges of samples
		8, Exposed edges	*C.l.*	*	*	Patches of nibbles on edges of samples
	Nylon 6.6 (A100 M Natural). 0·125 in. sheet	8, Exposed edges	*N.e.*	*	*	Isolated small patches of nibbles on edges of samples
		8, Exposed edges	*C.l.*	*	*	Patches of nibbles on edges of samples
	Nylon 610 (B100 C Natural). 0·125 in. sheet	8, Exposed edges	*N.e.*	*	*	Isolated small patches of nibbles on edges of samples
		8, Exposed edges	*C.l.*	*	*	Patches of nibbles on edges of samples
	Nylon 610 (B102 C Brown, light stabilized). 0·125 in. sheet	8, Exposed edges	*N.e.*	*	*	Isolated small patches of nibbles on edges of samples
		8, Exposed edges	*C.l.*	*	*	Patches of nibbles on edges of samples
41	High-tensile nylon. 0·02 in. sheet	8, Exposed edges	*N.e.*	0·003	0·015	Slight attack on 1 sample, nibbles on edges of other 7
		8, Masked edges	*C.l.*	*	*	Nibbles on edges of 7 samples
		8, Exposed edges	*C.l.*	*	*	No visible attack
		8, Exposed edges	*C.a.*	0·025	1·20	Slight attack on 7 samples (from edges), nibbles on 1
		8, Masked edges	*C.a.*	*	*	No visible attack
		4, Exposed edges	*M.d.*	+	+	Nibbles on edges of all samples
		4, Masked edges	*M.d.*	+	+	No visible attack
42	Cable. 0·28 in. diam. Polythene-insulated, sheathed with nylon 11 compound containing 2% carbon black. (Airfield lighting cable)	8, Capped	*N.e.*	*	*	No visible attack
		8, Capped	*C.l.*	*	*	No visible attack
		8, Uncapped	*C.a.*	0·146	0·5	Attack on ends of 5 samples, nibbles on other 3
		8, Capped	*C.a.*	*	*	No visible attack
		2, Uncapped	*M.d.*	0·009	0·12	Nibbles on ends of both samples
		2, Capped	*M.d.*	*	*	No visible attack
43	Cable. Polythene-sheathed, with 0·030 in. thick nylon 11 jacket	2, Uncapped	*N.e.*	0·015	0·5	Slight attack on sheath and jacket from ends
		2, Capped	*N.e.*	*	*	No visible attack
		2, Uncapped	*C.l.*	0·056	0·5	Nibbles on ends of sheath
		2, Capped	*C.l.*	*	*	No visible attack
		2, Uncapped	*C.a.*	0·500	4·45	Attack on sheath and jacket from ends of all samples
		2, Capped	*C.a.*	*	*	No visible attack

TABLE 1 (*Continued*)

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. (g)	Eaten (%)	Remarks
		Nylon (Continued)				
44	Cable. Jacketed with nylon 610. insulated with polythene	8, Uncapped	*N.e.*	0·020	0·26	Slight attack on jacket and insulant at ends of samples only
		8, Capped	*N.e.*	*	*	No visible attack
		8, Uncapped	*C.a.*	0·191	2·46	Conductor exposed at ends of 4 samples, attack mainly on insulant
45	Tubing. 0·25 in. O.D., nylon 11 (BESNO grade)	8, Capped	*C.a.*	0·002	0·03	Nibbles on jackets of all samples
		2, Capped	*N.e.*	*	*	No visible attack
		4, Capped	*C.l.*	*	*	No visible attack
		4, Capped	*C.a.*	*	*	No visible attack
		2, Uncapped	*M.d.*	*	*	Some nibbles on cut ends of samples
		2, Capped	*M.d.*	*	*	No visible attack
		Cellulose Esters				
46	Cellulose acetate butyrate plasticized with 7% aliphatic sebacate (0·094 in. thick)	8, Exposed edges	*N.e.*	0·42	1·85	Nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·27	1·1	Nibbles on edges of all samples
		8, Exposed edges	*C.a.*	0·41	1·9	All samples slightly attacked
	Cellulose acetate butyrate plasticized with 7% aliphatic azelate (0·094 in. thick)	8, Exposed edges	*N.e.*	0·28	1·2	Nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·22	0·9	Nibbles on edges of all samples
		8, Exposed edges	*C.a.*	0·43	2·0	All samples slightly attacked
47	Cellulose acetate butyrate piping, 0·75 in. I.D.	2, Ends plugged with C.A.B. bushes	*N.e.*	0·64	0·95	Areas of slight attack, penetration of pipe wall
		2, As above	*C.l.*	0·65	0·88	Areas of slight attack, penetration of pipe wall
		4, As above	*C.a.*	1·56	2·32	Several penetrations of pipe wall
48	Cellulose acetate butyrate (Tenite II). (0·094 in. thick pipe wall)	8, Exposed edges	*N.e.*	0·28	0·95	Nibbles on edges of samples
		8, Exposed edges	*C.l.*	*	*	No visible attack
49	Pipe. 1·25 in. O.D., cellulose acetate butyrate (Cellidor BMH 15 001 EK)	2, Uncapped	*N.e.*	0·021	0·72	Nibbles at ends of both samples
		2, Capped	*N.e.*	*	*	No visible attack
		2, Uncapped	*C.l.*	0·021	0·72	Nibbles on ends of both samples
		2, Capped	*C.l.*	*	*	No visible attack
		2, Uncapped	*C.a.*	0·325	1·12	Samples attacked at ends, several holes through walls
		2, Capped	*C.a.*	0·185	0·64	One hole through wall of one sample
50	Cellulose acetate butyrate piping, Cellidor B15 001 MHP. (1 in. I.D., 0·0625 in. wall thickness)	2, Uncapped ends	*N.e.*	0·05	0·38	Some nibbles on ends of samples
		2, Uncapped ends	*C.l.*	0·08	0·60	Some nibbles on ends of samples
		2, Uncapped ends	*C.a.*	0·21	0·95	Three penetrations of walls, attack on ends of samples
		1, Uncapped ends	*M.d.*	*	*	Nibbles on ends of sample
		Polyester Resins				
51	Plastrene 37, unfilled (0·15 in. thick)	8, Exposed edges	*N.e.*	0·07	0·15	Slight roughening of surface of samples
		8, Exposed edges	*C.l.*	*	*	No visible attack

	Plastrene 37 – 50 % chopped glass strand mat (0·10 in. thick)	8, Exposed edges	*N.e.*	0·22	0·58	Slight deterioration of surface and edges of samples
		8, Exposed edges	*C.l.*	0·09	0·25	Slight deterioration of surface and edges of samples
	Plastrene 37 – 65 % glass cloth (0·10 in. thick)	8, Exposed edges	*N.e.*	0·59	1·40	Slight deterioration of surface and edges of samples
		8, Exposed edges	*C.l.*	0·58	1·55	Slight deterioration of surface and edges of samples
	Plastrene 47, unfilled (0·15 in. thick)	8, Exposed edges	*N.e.*	0·24	0·60	Slight roughening of surface of samples
		8, Exposed edges	*C.l.*	0·07	0·30	Slight roughening of surface of samples
	Plastrene 47 – 47 % chopped glass strand mat (0·11 in. thick)	8, Exposed edges	*N.e.*	0·52	1·45	Slight deterioration of surface and edges of samples
		8, Exposed edges	*C.l.*	0·36	1·15	Deterioration of surface of samples
	Plastrene 47 – 68 % glass cloth (0·10 in. thick)	8, Exposed edges	*N.e.*	1·06	2·60	Slight deterioration of surface and edges of samples
		8, Exposed edges	*C.l.*	1·01	2·45	Deterioration of surface of samples
52	Sheet 0·375 in. thick. Flexible isophthalic acid modified polyester resin (Polylite 8130)	8, Strips	*N.e.*	*	*	No visible attack
		8, Strips	*C.l.*	*	*	No visible attack
53	Film (Melinex); 0·00175 in. thick	2, Flat	*N.e.*	+	+	Termites in contact with film, no visible damage
		2, Folded	*N.e.*	+	+	Termites in contact with film, no visible damage
		2, Flat	*C.l.*	+	+	Termites in contact with film, no visible damage
		2, Folded	*C.l.*	+	+	Termites in contact with film, no visible damage
		2, Flat	*C.a.*	+	+	Termites in contact with film, no visible damage
		2, Folded	*C.a.*	+	+	Termites in contact with film, no visible damage
54	Epikote 828 – 8 % triethylene tetramine (0·22 in. thick)	8, Exposed edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	*	*	No visible attack
	Epikote 828 – 11 % triethylene tetramine – 11 % Diluent S – 1 % di-tertiary butyl peroxide (0·25 in. thick)	8, Exposed edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	*	*	No visible attack
	Epikote 834 – 25 %. Diluent S – 12·5 % curing agent – 2·5 % di-tertiary butyl peroxide (0·22 in. thick)	8, Exposed edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	*	*	No visible attack
	Epikote 834 – 6 % piperidine (0·25 in. thick)	8, Exposed edges	*N.e.*	0·22	0·86	Traces of nibbles on surface of some samples only
		8, Exposed edges	*C.l.*	*	*	As above, but less evident
	Epikote 834 – 15 % m-phenylenediamine (0·25 in. thick)	8, Exposed edges	*N.e.*	0·02	0·13	Traces of nibbles on surface of some samples only
		8, Exposed edges	*C.l.*	*	*	As above, but less evident
55	Pipe, 3 in. diam., 0·31-in. wall thickness (glass and acrylic fibre bonded with thermo-setting epoxy resin)	4, Strips	*N.e.*	*	*	No visible attack
		4, Strips	*C.l.*	*	*	No visible attack
		4, Strips	*C.a.*	*	*	No visible attack
		1, Strips	*M.d.*	*	*	No visible attack
		Acetal Resins				
56	Sheet 0·094 in. thick (Delrin)	8, Strips	*N.e.*	*	*	No visible attack
		8, Strips	*C.l.*	*	*	No visible attack
		4, Strips	*C.a.*	0·004	0·03	Traces of nibbles on edges of all samples
57	Cable. Polyacetal copolymer jacket over polythene insulation	6, Uncapped	*N.e.*	0·022	0·32	Slight attack on jacket and insulant at ends of samples only
		6, Capped	*N.e.*	*	*	No visible attack
		6, Uncapped	*C.a.*	0·318	4·65	Conductor exposed at ends of 5 samples, mainly through attack on insulant
		6, Capped	*C.a.*	*	*	No visible attack

TABLE 1 (*Continued*)

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Remarks
		Natural and Synthetic Elastomers				
58	Natural rubber (cable sheath. Stock No. 22/51/1) 0·5-in. square strips	8, Exposed edges	*N.e.*	0·55	0·70	Localized areas of slight attack on samples
		8, Exposed edges	*C.l.*	0·55	0·72	Localized areas of slight attack on samples
		8, Exposed edges	*C.a.*	0·71	0·90	Localized areas of slight attack on samples
59	Natural rubber. Shore hardness 70 (0·5 in. thick)	8, Exposed edges	*N.e.*	0·80	1·90	Small patches of attack up to 0·06 in. deep
		8, Exposed edges	*C.l.*	0·34	0·85	Small patches of nibbles and slight attack
		8, Exposed edges	*C.a.*	0·36	1·15	Five samples with areas of slight attack
60	Polychloroprene (Neoprene). Shore hardness 60° (0·25 in. sheet)	8, Exposed edges	*N.e.*	0·16	0·45	Scattered patches of attack up to 0·06 in. deep
		8, Exposed edges	*C.l.*	*	*	Small isolated patches of nibbles
		8, Exposed edges	*C.a.*	*	*	Small areas of nibbles on edges of all samples
61	Polychloroprene (Neoprene). cable sheath, 0·44 in. diam.	8, Wax-sealed ends	*N.e.*	0·04	0·17	Two samples attacked, nibbles on other 6
		8, Wax-sealed ends	*C.l.*	0·16	0·71	Conductor exposed in 3 samples
62	Polyester isocyanate synthetic rubbers					
	Duralon 18 40. Shore hardness 65° (0·125-in.-thick sheet)	8, Exposed edges	*N.e.*	0·32	1·65	Nibbles along edges of all samples
		8, Exposed edges	*C.l.*	0·53	2·85	Nibbles on edges and faces of all samples
	Duralon 18. Shore hardness 80° (0·125-in.-thick sheet)	8, Exposed edges	*N.e.*	0·36	1·80	Nibbles on edges and faces of all samples
		8, Exposed edges	*C.l.*	0·65	3·35	Nibbles on edges and faces of all samples
	Duralon 30. Shore hardness 94° (0·125-in.-thick sheet)	8, Exposed edges	*N.e.*	0·43	2·20	Nibbles on edges and faces of all samples
		8, Exposed edges	*C.l.*	0·47	2·35	Nibbles on edges and faces of all samples
63	Polychloroprene (Neoprene 2543A. sheet). Shore hardness 70°	8, Exposed edges	*N.e.*	0·09	0·9	Isolated patches of nibbles on samples
		8, Exposed edges	*C.l.*	0·26	2·6	Three samples slightly attacked
64	Polysulphide rubber (Thiokol 2534B, sheet). Shore hardness 55°	8, Exposed edges	*N.e.*	0·17	1·8	Two samples attacked, 6 with nibbles
		8, Exposed edges	*C.l.*	2·08	22·4	All samples slightly to badly attacked
65	Sheet. 0·03 in. thick (Esso butyl rubber)	2, Flat	*N.e.*	+	+	Termites in contact with sheet, no visible attack
		2, Folded	*N.e.*	+	+	Termites in contact with sheet, surface nibbles on fold
		2, Flat	*C.l.*	+	+	Two penetrations of sheet and several areas of attack
		2, Folded	*C.l.*	+	+	Thirteen penetrations of sheet
		2, Flat	*C.a.*	+	+	Termites in contact with sheet, no visible attack
		2, Folded	*C.a.*	+	+	One penetration of sheet, several areas of nibbles
		Various Plastics				
66	Copolymer of styrene–butadiene–acrylonitrile, with carbon black 1 in. I.D., Kralastic piping 0·0625 in. wall	2, Uncapped ends	*N.e.*	0·01	0·06	Traces of nibbles on ends of both samples
		2, Uncapped ends	*C.l.*	*	*	Traces of nibbles on ends of both samples
		2, Uncapped ends	*C.a.*	*	*	Extensive surface nibbles on both samples
67	Copolymer of styrene–butadiene–acrylonitrile, 1 in. diam. Kralastic piping	2, Self-capped ends	*N.e.*	*	*	No visible attack
		2, As above	*C.l.*	*	*	No visible attack
		2, As above	*C.a.*	0·22	0·85	Extensive areas of slight attack up to 0·03 in. deep

68	Polyvinylidene chloride (0·0015-in. film)	8, Film wrapped around timber samples	*N.e.*	*	*	30–60 % of film destroyed
			C.l.	*	*	Approximately 30 % of film destroyed
69	Polycarbonic acid ester of 4,4′-dihydroxydiphenyl 2,2-propane, 0·18 in. thick sheet (Makrolon)	8, Exposed edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	*	*	No visible attack
		8, Exposed edges	*C.a.*	‡	‡	No visible attack
70	Polyisobutylene, sheet 0·094 in. thick	8, Exposed edges	*C.a.*	0·61	3·60	Six samples attacked, 2 slightly attacked
		8, Masked edges	*C.a.*	0·31	1·80	Three samples attacked (holes through sheet), 2 slightly attacked
71	Polytetrafluorethane, sheet 0·0625 in. thick (Emralon)	8, Masked edges	*C.l.*	*	*	Nibbles on face of 5 samples
		8, Exposed edges	*C.l.*	0·004	0·03	Nibbles on edges of all samples
		8, Exposed edges	*C.a.*	0·075	0·49	Nibbles on edges of all samples
72	Phenol-paper laminate, ammonia-catalysed, 0·0625 in. thick	8, Exposed edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	*	*	No visible attack
	Cresol-paper laminate, ammonia-catalysed, 0·18 in. thick	8, Exposed edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	*	*	No visible attack
	Cresol-fabric laminate, ammonia-catalysed, 0·25 in. thick	8, Exposed edges	*N.e.*	0·57	1·3	Roughening of surface on all samples
		8, Exposed edges	*C.l.*	0·22	0·5	Roughening of surface on all samples

* No measurable weight loss. † Samples not weighed. ‡ Small weight loss recorded but not confirmed by visual appearance of sample.

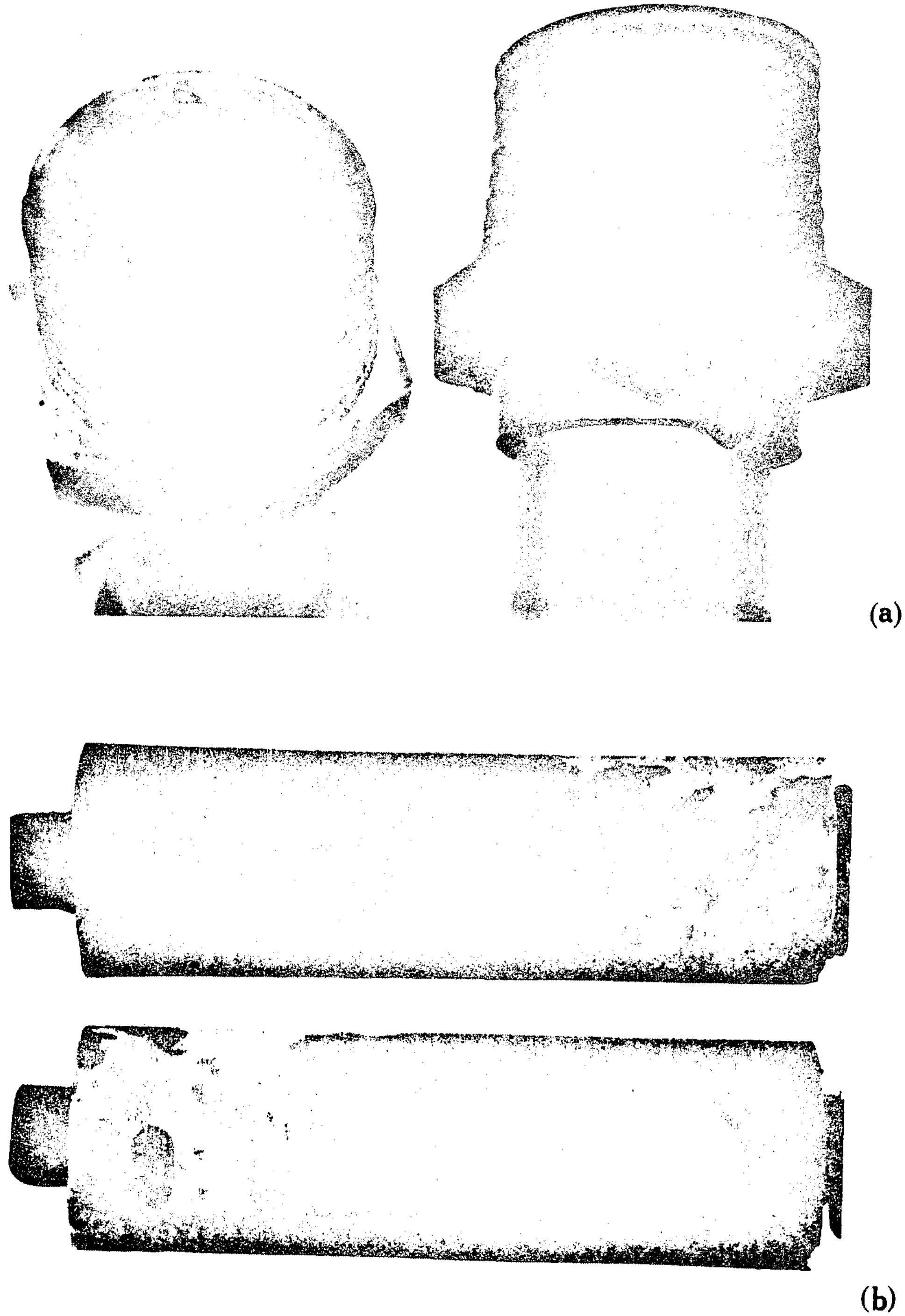


Fig. 3.—Samples of plastic piping after exposure to attack by *Coptotermes acinaciformis* in laboratory colonies. (*a*) Cellulose acetate butyrate; (*b*) polyethylene.

plasticized with dioctyl phthalate, irrespective of whether the level of tricresyl phosphate is adjusted to give a final product of equivalent hardness to that achieved using dioctyl phthalate. This finding must be treated with some reservation, however, as the compounds were matched for hardness at 20°C and tested at 26°C. The difference of 6 degC is sufficient to cause an appreciable variation in hardness, which will be different for each of the plasticizers.

In Test No. 4 (Table 2) the surface coating of polyurethane apparently delayed the initiation of attack. However, it is again evident that comparable susceptibility of polyvinyl chloride to termite attack occurs with lower levels of dioctyl phthalate and di-isooctyl phthalate plasticizers than with tricresyl phosphate.

Test No. 5 (Table 2) gives further proof of the decrease in termite resistance of polyvinyl chloride as the level of plasticizer rises. A point of interest here is the reversal in the trend of increasing susceptibility in the *C. lacteus* test, as the plasticizer level was raised from 59·5 to 69·5 parts per 100 parts resin. Survival figures for the experimental colonies indicated that no toxic effect was involved, and it is possible that a repellent action is operating.

In the cellulose acetate test there are four variables, any or all of which could conceivably affect the resistance of this material to termite attack. These four variables are colour (dyes or pigments), acetyl range (medium, high, or extra high), plasticizer range (low or medium), and plasticizer type (phthalate or phthalate plus phosphate). The significance of these factors was checked by a statistical analysis of the data which showed (i) that there is no difference in the resistance of cellulose acetate to attack whether the colour is due to dyes or to pigments, (ii) that phthalate plasticizer gives a more resistant product than phthalate plus phosphate plasticizer, (iii) that a low plasticizer range gives better termite resistance than a medium range, and (iv) that a high acetyl range yields a more resistant product than a medium acetyl range but an extra high range is no better than a high range. There is interaction between the three variables, plasticizer type, plasticizer range, and acetyl range, and the most satisfactory combination to increase the termite resistance of cellulose acetate is high acetyl range, low plasticizer range, and phthalate plasticizer.

Two conclusions may be drawn from this series of tests on the effects of plasticizer variation. Firstly, the termite susceptibility of plastics such as polyvinyl chloride and cellulose acetate increases as the level of plasticizer is increased. Secondly, for those applications in which plasticizing is essential, termite susceptibility can be lessened by the correct choice of plasticizer, i.e. tricresyl phosphate for polyvinyl chloride and dioctyl phthalate for cellulose acetate.

(*c*) *Influence of Physical Factors*

In addition to the chemical formulation of a plastic, physical factors such as thickness and surface texture could be expected to influence its susceptibility to termite attack. In Section I reference is made to overseas opinion that thickness is important in this respect, and two series of tests to check this point are summarized in Table 3. In both tests the results show clearly that the susceptibility of polyvinyl chloride is inversely related to thickness—the thinner the film or foil, the greater the amount of attack. This finding has some relevance in view of the increasing use of plastic sheeting

TABLE 2

LABORATORY TESTS OF EFFECTS OF VARIATION IN PLASTICIZER ON TERMITE RESISTANCE OF PLASTICS

N.e., *Nasutitermes exitiosus*; *C.l.*, *Coptotermes lacteus*; *C.a.*, *Coptotermes acinaciformis*; B.S.H., British Standard Hardness; B.S.S., British Standard Softness

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Remarks
		Polyvinyl Chloride				
1	Unplasticized, white lead stabilized, 0·1 in. thick sheet	8, Exposed edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	+	+	No visible attack
	100 parts Corvic DR – 30 dioctyl phthalate – 6 white lead, 0·1 in. thick sheet	8, Exposed edges	*N.e.*	0·14	0·6	Extensive nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·25	1·2	Two samples attacked, extensive nibbles to slight attack on 6
	100 parts Corvic DR – 30 tricresyl phosphate – 6 white lead, 0·1 in. thick sheet	8, Exposed edges	*N.e.*	0·02	0·1	Traces of nibbles on edges of some samples only
		8, Exposed edges	*C.l.*	0·05	0·2	Small isolated patches of nibbles on some samples
	100 parts Corvic DR – 30 dioctyl phthalate – 2 calcium stearate, 0·1 in. thick sheet	8, Exposed edges	*N.e.*	0·21	0·85	Extensive nibbles on edges of all samples
		8, Exposed edges	*C.l.*	1·02	4·45	Four samples attacked, 4 with extensive nibbles to slight attack
	100 parts Corvic DR – 30 tricresyl phosphate – 2 calcium stearate, 0·1 in. thick sheet	8, Exposed edges	*N.e.*	0·10	0·45	Isolated small patches of nibbles on edges of samples
		8, Exposed edges	*C.l.*	0·01	0·06	Isolated small patches of nibbles on some samples only
2	100 parts Corvic D65 2 – 40 dioctyl phthalate (B.S.H. 90), 0·1 in. thick sheet	8, Exposed edges	*N.e.*	0·34	3·55	Two samples slightly attacked, 6 with extensive nibbles
		8, Exposed edges	*C.l.*	0·45	4·55	Five samples attacked, 2 slightly attacked
	100 parts Corvic D65 2 – 40 tricresyl phosphate (B.S.H. 96), 0·1 in. thick sheet	8, Exposed edges	*N.e.*	0·04	0·4	Small patches of nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·07	0·6	Extensive nibbles, very obvious on 3 samples
	100 parts Corvic D65 2 – 40 di-isooctyl phthalate (B.S.H. 90), 0·1 in. thick sheet	8, Exposed edges	*N.e.*	0·26	2·45	Four samples slightly attacked, 4 with edge nibbles
		8, Exposed edges	*C.l.*	0·47	4·45	Two samples attacked, 6 slightly attacked
3	100 parts Corvic D65 2 – 47·5 dioctyl phthalate (B.S.H. 88), 0·125 in. thick sheet	8, Exposed edges	*C.l.*	1·92	18·8	All 8 samples badly attacked
	100 parts Corvic D65 2 – 51·8 tricresyl phosphate (B.S.H. 86), 0·125 in. thick sheet	8, Exposed edges	*C.l.*	1·54	15·1	All 8 samples badly attacked
	100 parts Corvic D65 2 – 47·5 tricresyl phosphate (B.S.H. 94), 0·125 in. thick sheet	8, Exposed edges	*C.l.*	0·52	4·7	Seven samples slightly attacked, 1 with nibbles only
	100 parts Corvic D65 2 – 43·5 dioctyl phthalate (B.S.H. 94), 0·125 in. thick sheet	8, Exposed edges	*C.l.*	1·31	14·0	All 8 samples attacked to badly attacked
4	PVC, 0·125 in. thick sheet (Corvic D65 8, D.O.P. plasticizer, 47·5 parts/100 base resin) double coated with polyurethane (Daltosec 158)	4, Exposed edges	*N.e.*	0·352	1·88	One sample attacked, 1 slightly attacked on ends, 2 sound
		2, Exposed edges	*C.l.*	0·078	0·82	One sample slightly attacked (at end), nibbles on 2 (film breached)
	As above, but plasticized with D.O.P. 40 parts/100 base resin	4, Exposed edges	*C.a.*	0·488	2·50	One sample attacked, 3 slightly attacked (film breached)
		4, Exposed edges	*N.e.*	0·303	1·77	One sample attacked, 3 slightly attacked (on ends)
		2, Exposed edges	*C.l.*	0·071	0·79	One sample slightly attacked (at end), nibbles on 1
	As above, but plasticized with D.I.O.P. 40 parts/100 base resin	4, Exposed edges	*C.a.*	0·483	2·70	Two samples attacked, 2 slightly attacked
		4, Exposed edges	*N.e.*	0·243	1·49	Two samples attacked, 1 slightly attacked, nibbles on 1 (on ends)
	As above, but plasticized with T.C.P. 51·8 parts/100 base resin	2, Exposed edges	*C.l.*	0·041	0·50	Nibbles on 2 samples (film breached)
		4, Exposed edges	*C.a.*	0·651	3·93	Four samples slightly attacked (film breached)
		4, Exposed edges	*N.e.*	0·261	1·30	Three samples slightly attacked, nibbles on 1 (on ends)
		2, Exposed edges	*C.l.*	0·132	1·35	One sample slightly attacked (at end), 1 sample sound
		4, Exposed edges	*C.a.*	0·536	2·76	One sample attacked, 3 slightly attacked

5	PVC, 0·0625 in. thick sheet, 30 parts plasticizer 100 parts resin, density 1·33,	6, Exposed edges	*N.e.*	0·016	0·28	Nibbles on edges of all 6 samples
	B.S.H. at 26°C 98, B.S.S. at 26°C 8	8, Exposed edges	*C.I.*	0·065	0·87	Six samples slightly attacked, extensive nibbles on 2
	As above, 39·5 parts plasticizer 100 parts resin, density 1·30, B.S.H. at	6, Exposed edges	*N.e.*	0·058	1·19	One sample attacked, 1 slightly attacked, nibbles on 4
	26°C 92, B.S.S. at 26°C 21	8, Exposed edges	*C.I.*	0·752	11·75	One sample badly attacked, 7 attacked
	As above, 49·5 parts plasticizer 100 parts resin, density 1·28 B.S.H. at	6, Exposed edges	*N.e.*	0·063	1·17	Four samples slightly attacked, nibbles on 2
	26°C 86, B.S.S. at 26°C 27	8, Exposed edges	*C.I.*	1·285	18·70	Four samples badly attacked, 4 attacked
	As above, 59·5 parts plasticizer 100 parts resin, density 1·25, B.S.H. at	6, Exposed edges	*N.e.*	0·061	1·24	One sample attacked, 1 slightly attacked, nibbles on 4
	26°C 84, B.S.S. at 26°C 33	8, Exposed edges	*C.I.*	1·475	21·45	Five samples badly attacked, 3 attacked
	As above, 69·5 parts plasticizer 100 parts resin, density 1·23, B.S.H. at	6, Exposed edges	*N.e.*	0·114	2·22	One sample attacked, 3 slightly attacked, nibbles on 2
	26°C 79, B.S.S. at 26°C 36	8, Exposed edges	*C.I.*	0·840	12·70	Two samples badly attacked, 6 attacked
		Cellulose Acetate				
6	Transparent crystal, dyed, medium acetyl range, medium phthalate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	1·24	19·85	Four samples destroyed, 4 slightly to badly attacked
	Opaque white, pigmented, medium acetyl range, medium phthalate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	1·09	11·85	Three samples destroyed, 5 slightly attacked to attacked
	Translucent cream, pigmented, medium acetyl range, low phthalate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	0·30	4·05	One sample destroyed, 3 slightly attacked to attacked, 4 sound
	Translucent cream, pigmented, high acetyl range, medium phthalate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	0·61	7·30	Two samples destroyed, 6 slightly attacked to attacked
	Transparent blue, dyed, high acetyl range, medium phthalate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	0·54	9·55	Two samples destroyed, 6 slightly attacked to attacked
	Transparent brown, dyed, high acetyl range, low phthalate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	0·34	4·30	One sample destroyed, 7 showing nibbling to attack
	Translucent brown, pigmented, high acetyl range, low phthalate – phosphate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	0·25	3·00	One sample destroyed, 6 showing nibbles to slight attack, 1 sound
	Transparent crystal, dyed, high acetyl range, low phthalate – phosphate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	0·17	2·75	One sample destroyed, 4 showing nibbles to slight attack, 3 sound
	Opaque white, pigmented, extra high acetyl range, low phthalate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	0·15	2·25	One sample destroyed, 2 showing nibbles to slight attack, 5 sound
	Grey, pigmented, medium acetyl range, low phthalate – phosphate range; 0·125 in. diam. rod	8, Uncapped ends	*C.I.*	0·60	9·95	Two samples destroyed, 3 slightly attacked to attacked, 3 sound

* Small weight loss recorded, but not confirmed by visual appearance of sample. † No measurable weight loss.

TABLE 3

LABORATORY TESTS OF EFFECT OF VARIATION IN THICKNESS ON TERMITE RESISTANCE OF POLYVINYL CHLORIDE

N.e., *Nasutitermes exitiosus*; *C.l.*, *Coptotermes lacteus*

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Remarks
1	Rigid foil, 0·0012 in. thick	8, Film wrapped around timber samples	*N.e.*	*	*	Extensive penetration of film and attack on timber cores
		8, Film wrapped around timber samples	*C.l.*	*	*	Extensive damage to film and attack on timber cores
	Rigid foil, 0·0048 in. thick	8, Hollow rolled tubes	*N.e.*	0·008	0·70	Few nibbles only on edges of 4 samples
		8, Hollow rolled tubes	*C.l.*	0·08	0·70	Numerous areas of slight attack up to $\frac{3}{16}$ in. from edges
	Rigid foil, 0·010 in. thick	8, Hollow rolled tubes	*N.e.*	0·06	0·35	Traces of nibbles on edges of 3 samples
		8, Hollow rolled tubes	*C.l.*	0·06	0·30	Few nibbles only on edges of samples
2	Rigid foil based on Corvic H55/34; 0·005 in. thick	3, Hollow rolled tubes	*N.e.*	†	†	One sample slightly attacked, nibbles on edges of 2
		3, Hollow rolled tubes	*C.l.*	†	†	One sample slightly attacked, nibbles on edges of 2
	As above, 0·01 in. thick	3, Hollow rolled tubes	*N.e.*	†	†	Few nibbles on edges of all samples
		3, Hollow rolled tubes	*C.l.*	†	†	All samples sound
	As above, 0·02 in. thick	3, Hollow rolled tubes	*N.e.*	†	†	Few nibbles on edges of 2 samples, 1 sound
		3, Hollow rolled tubes	*C.l.*	†	†	All samples sound
	Semi-rigid foil based on Breon 202 plasticized with D.O.P. and dicyclohexyl phthalate; 0·005 in. thick	3, Hollow rolled tubes	*N.e.*	†	†	One sample attacked, 1 slightly attacked, 1 with edge nibbles
		3, Hollow rolled tubes	*C.l.*	†	†	Two samples attacked, 1 slightly attacked
	As above, 0·01 in. thick	3, Hollow rolled tubes	*N.e.*	†	†	Nibbles on edges of all samples
		3, Hollow rolled tubes	*C.l.*	†	†	Nibbles on edges of 2 samples only
	As above, 0·02 in. thick	3, Hollow rolled tubes	*N.e.*	†	†	Nibbles on edges of 1 sample only
		3, Hollow rolled tubes	*C.l.*	†	†	No visible attack

* Plastic material not weighed separately. † No measurable weight loss.

for damp-proofing, particularly under concrete-slab construction. In order to minimize the risk of termite damage to the plastic membrane, the thickest grade that is economically feasible should be used.

By far the commonest forms in which termites are likely to encounter plastics, however, are piping or cable sheathing. Both these types of product generally present the termites with a surface relatively free from edges or irregularities other than the minor abrasions and scratches sustained during installation. It is not unreasonable to suppose that a curved, unblemished plastic surface offers little opportunity for the initiation of termite attack and that the damage sustained by cables and piping originates from surface imperfections. If this is actually so, then special precautions in processing or installation, or both, to ensure a smooth surface finish on the plastic should minimize termite attack.

This point was checked in a test in which samples of a semi-rigid and a plasticized polyvinyl chloride were given a variety of surface finishes by sanding with different grades of abrasive paper before exposure to termite activity. The results are summarized in Table 4, and it can be seen that none of the treatments had any effect on the termite susceptibility of the finished plastic. It is concluded from this test that the physical nature of the surface of a plastic is of no importance in determining the liability of the plastic to termite attack.

In a series of tests on polyethylene, the effects on termite resistance of other physical factors such as density, molecular weight, and melt flow index* were examined. The results of these tests are summarized in Table 5. The data for Test No. 1 in Table 5 indicate that, if density and the nature of any fillers or additives are kept constant, polyethylene with a high melt flow index is more susceptible to attack than one with a low melt flow index. There is partial confirmation of this finding in Test No. 2, in which the high melt flow index polyethylene without additives is much more susceptible than the low melt flow index material. In the samples containing carbon black, however, the influence of melt flow index is not apparent. In both tests the addition of 10% butyl rubber (polyisobutylene) for the purpose of improving processing qualities adversely affected the termite resistance of the end product.

Test No. 3 (Table 5) clearly demonstrates the greater termite resistance of high molecular weight polyethylene compared to the low molecular weight polymer. In general this is confirmed by the results of Test No. 4 (Table 5). However, the critical molecular weight appears to be around 50,000, and increases beyond this figure produce only very slight improvements in resistance to attack.

In Test No. 5 (Table 5) a group of high-density polyethylenes showed consistently lower levels of attack than a number of low-density polyethylenes. The pattern of attack on the low-density polymers in relation to melt flow index is slightly anomalous; in the *N. exitiosus* tests the more usual pattern of an increased level of attack on high melt flow index material is evident, but in the *C. lacteus* tests the second of the high flow index polyethylenes (density 0·923) proved more resistant than low melt flow index material.

* Melt flow index or melt index is primarily an assessment of the flow properties of the material and is a function of the molecular weight. A low melt index indicates a high molecular weight with maximum toughness and resistance to stress cracking. Conversely, a high melt index indicates a lower molecular weight with improved processing qualities but with reduced toughness and resistance to stress cracking.

TABLE 4

LABORATORY TESTS OF EFFECT OF VARIATIONS IN SURFACE FINISH ON TERMITE RESISTANCE OF POLYVINYL CHLORIDE

N.e., Nasutitermes exitiosus; C.l., Coptotermes lacteus

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Remarks
1	Semi-rigid PVC. based on Breon 202, plasticized with D.O.P. and dicyclohexyl phthalate, surface highly polished	8, Exposed edges	*N.e.*	0·01	0·1	Seven samples with a few nibbles on edges
		8, Exposed edges	*C.l.*	*	*	No visible attack
	As above, but surface sanded with fine-grade paper	8, Exposed edges	*N.e.*	0·02	0·2	Five samples with a few nibbles on edges
		8, Exposed edges	*C.l.*	*	*	No visible attack
	As above, but surface sanded with medium-grade paper	8, Exposed edges	*N.e.*	0·01	0·1	Five samples with a few nibbles on edges
		8, Exposed edges	*C.l.*	*	*	No visible attack
	As above, but surface sanded with coarse-grade paper	8, Exposed edges	*N.e.*	0·02	0·2	Five samples with a few nibbles on edges
		8, Exposed edges	*C.l.*	*	*	No visible attack
2	Standard PVC, based on Corvic D62 2, plasticized with D.O.P., surface highly polished	8, Exposed edges	*N.e.*	0·08	1·20	Two samples slightly attacked, nibbles on edges of 6
		8, Exposed edges	*C.l.*	0·60	8·30	Three samples attacked, 4 slightly attacked, 1 with edge nibbles
	As above, but sanded with fine-grade paper	8, Exposed edges	*N.e.*	0·10	1·45	One sample slightly attacked, 7 with edge nibbles
		8, Exposed edges	*C.l.*	0·37	5·25	One sample attacked, 7 slightly attacked
	As above, but sanded with medium-grade paper	8, Exposed edges	*N.e.*	0·14	1·85	Five samples slightly attacked, 3 with edge nibbles
		8, Exposed edges	*C.l.*	0·54	7·05	Four samples attacked, 4 slightly attacked
	As above, but sanded with coarse-grade paper	8, Exposed edges	*N.e.*	0·08	1·15	Nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·76	9·50	One sample badly attacked, 5 attacked, 2 slightly attacked

* No measurable weight loss.

In the last test in this group (No. 6, Table 5), the results show that cross-linked curing of polyethylene is of no value in producing a termite-resistant product.

The general conclusions to be drawn from the above group of tests are that polyethylene varies very widely in its natural resistance to termite attack and the desirable properties for high resistance are a low melt flow index, high density, and high molecular weight.

(*d*) *Incorporation of Insecticides*

The tests so far reported in this paper show that some plastics in widespread use, such as plasticized polyvinyl chloride and low-density polyethylene, are liable to severe termite damage. This is confirmed by many field observations and has led to considerable interest in attempting to prevent such damage by the addition of various insecticidal materials during processing. A number of manufacturers have experimented with such additives, mainly of the chlorinated aromatic or cyclodiene type, and Table 6 presents a summary of a series of tests to determine the effectiveness or otherwise of these materials in reducing termite attack.

Figures for the percentages of insecticidal materials present are nominal retentions only, and no information is available on actual retentions. It is not known, therefore, whether any loss of insecticide has occurred during processing but, in view of the thermal instability of some compounds and the high temperatures associated with processing, losses could be expected. For this reason, and also because of variations in the composition of base mixes, no valid comparisons can be made between different tests and each must be considered as a separate entity.

The ratings given in the toxicity column of Table 6 are based on a comparison of the survival times of colonies containing treated samples with those of unfed control colonies. The length of life of the latter measures the normal death rate from starvation, and the number of days by which the life of test colonies falls short of this figure is taken as a measure of the toxicity of materials included in such colonies. The rating "v. slight" indicates that the survival of the colonies concerned was only 1 or 2 days less than that of the unfed colonies, and that toxic action is doubtful.

In Test No. 1 (Table 6) all samples were attacked more heavily by *C. lacteus* than by *N. exitiosus*. Although the level of attack fell as the concentration of "1368" (chlorinated aryl sulphonamide) increased, even at the highest loading tested (2%) complete immunity to attack was not obtained. No untreated control material was available for this test, but untreated polyvinyl chloride of similar composition to the base mix was tested one year previously with the following results: *N. exitiosus*, 0·7 g (4·6%) eaten; *C. lacteus*, 0·17 g (2·1%) eaten. Even allowing for some variation in the vitality of the termites used in the two separate series of tests, these figures suggest that although the lowest loading of "1368" tested (0·2%) has a deterrent effect on *N. exitiosus* this effect does not occur with *C. lacteus* until a loading of 1% is reached.

Test No. 2 (Table 6) shows that this untreated grade of polyvinyl chloride is slightly susceptible to termite attack, more particularly by *C. lacteus*. The addition of Xylamon GI (chlorinated naphthalene) lowers this susceptibility progressively with increasing concentration, but even at the highest loading tested (2%) does not give

TABLE 5

LABORATORY TESTS OF EFFECTS OF VARIATIONS IN PHYSICAL PROPERTIES ON TERMITE RESISTANCE OF POLYETHYLENE

N.e., *Nasutitermes exitiosus*; *C.l.*, *Coptotermes lacteus*; *C.a.*, *Coptotermes acinaciformis*

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Remarks
1	Polyethylene, melt flow index 0·2, density 0·919, –1% slip additive (strips, 0·0625 in. thick)	8, Exposed edges	*N.e.*	0·021	0·40	Nibbles on edges of all samples, extensive on 4
		8, Exposed edges	*C.l.*	0·133	2·65	One sample badly attacked, 1 attacked, 5 slightly attacked
	Polyethylene, melt flow index 2·0, density 0·919, –1% slip additive (strips, 0·0625 in. thick)	8, Exposed edges	*N.e.*	0·032	0·70	Nibbles on edges of all samples, extensive on 2
		8, Exposed edges	*C.l.*	0·295	6·50	Three samples badly attacked, 4 attacked, 1 slightly attacked
	Polyethylene, melt flow index 2·0, density 0·931, –2·5% carbon black (strips, 0·0625 in. thick)	8, Exposed edges	*N.e.*	0·037	0·80	Slight attack on 2 samples, edge nibbles on 6
		8, Exposed edges	*C.l.*	0·232	5·10	Five samples badly attacked, 2 attacked, 1 slightly attacked
	Polyethylene, melt flow index 0·8, density 0·934, –2·5% carbon black (strips, 0·0625 in. thick)	8, Exposed edges	*N.e.*	0·013	0·30	Nibbles on edges of 7 samples, 1 sound
		8, Exposed edges	*C.l.*	0·146	3·05	Four samples attacked, 4 slightly attacked
	Polyethylene, melt flow index 0·3, density 0·932, –2·5% carbon black (strips, 0·0625 in. thick)	8, Exposed edges	*N.e.*	0·019	0·35	Nibbles on 7 samples, 1 sound
		8, Exposed edges	*C.l.*	0·185	3·45	Four samples attacked, 4 slightly attacked
	Polyethylene, melt flow index 2·0, density 0·930, –10% butyl rubber (strips, 0·0625 in. thick)	8, Exposed edges	*N.e.*	0·075	1·65	Attack on 1 sample, slight attack on 3, nibbles on 4
		8, Exposed edges	*C.l.*	0·333	7·25	Five samples badly attacked, 3 attacked
2	Polyethylene sheet 0·0625 in. thick, melt flow index 2·0, base polymer density 0·92 – 2% carbon black and 10% butyl rubber (D11 32)	8, Exposed edges	*N.e.*	0·030	0·70	Slight attack on 2 samples, nibbles on 6
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	0·415	9·50	One sample badly attacked, 4 attacked, 3 slightly attacked
		8, Masked edges	*C.l.*	0·041	0·95	Nibbles on faces and edges of 5 samples
	Polyethylene sheet 0·0625 in. thick, melt flow index 2·0, base polymer density 0·92, –2% carbon black (B11 04)	8, Exposed edges	*N.e.*	0·021	0·40	Slight attack on 1 sample, nibbles on 7
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	0·240	4·70	One sample attacked, 6 slightly attacked, nibbles on 1
		8, Masked edges	*C.l.*	0·014	0·30	Nibbles on edges and faces of 2 samples
	Polyethylene sheet 0·0625 in. thick, melt flow index 0·3, base polymer density 0·92, –2% carbon black (DFDL 6015)	8, Exposed edges	*N.e.*	0·011	0·18	Nibbles on edges of 8 samples
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	0·278	3·20	Seven samples slightly attacked, nibbles on 1
		8, Masked edges	*C.l.*	0·022	0·40	Nibbles on faces of 8 samples
	Polyethylene sheet 0·0625 in. thick, melt flow index 0·3, base polymer density 0·92 (DFDL 6005)	8, Exposed edges	*N.e.*	0·004	0·13	Nibbles on edges of 8 samples
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	0·133	3·45	Three samples attacked, 5 slightly attacked
		8, Masked edges	*C.l.*	0·016	0·50	Nibbles on faces of 7 samples
	Polyethylene sheet 0·0625 in. thick, melt flow index 2·0, base polymer density 0·92 (DFDL 2005)	8, Exposed edges	*N.e.*	0·008	0·13	Nibbles on edges of 8 samples
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	0·247	4·20	One sample attacked, 6 slightly attacked, nibbles on 1
		8, Masked edges	*C.l.*	0·037	0·65	Nibbles on faces of 5 samples
3	Polyethylene sheet 0·0625 in. thick, mol. wt. 45,000, density 0·922 (XDG 33)	8, Exposed edges	*N.e.*	0·009	0·14	Nibbles on edges of all 8 samples
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.a.*	0·305	4·75	Two samples attacked, 6 slightly attacked
		8, Masked edges	*C.a.*	*	*	No visible attack
	As above, mol. wt. 24,000, density 0·922 (XRM 21)	8, Exposed edges	*N.e.*	0·042	0·77	Extensive nibbles on edges of all 8 samples
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.a.*	0·711	13·30	Five samples badly attacked, 2 attacked, 1 slightly attacked
		8, Masked edges	*C.a.*	*	*	Nibbles on surface of 1 sample

4	Polyethylene sheet 0·0625 in. thick, or 1 in. O.D. pipe (GB 6450, white Hostalen, mol. wt. c. 50,000)	8, Strips (exposed edges)	*N.e.*	0·017	0·28	Nibbles on edges of all 8 samples
		2, Pipe (uncapped)	*C.l.*	0·016	0·07	Extensive nibbles on ends of both samples
		2, Pipe (uncapped)	*C.a.*	0·088	0·49	Slight attack on ends of both samples
	As above (GC 6465, white Hostalen, mol. wt. - 50,000)	8, Strips (exposed edges)	*N.e.*	0·021	0·35	Nibbles on edges of all 8 samples
		2, Pipe (uncapped)	*C.l.*	0·054	0·25	Slight attack on end of 1 sample, nibbles on remaining ends
		2, Pipe (uncapped)	*C.a.*	0·101	0·67	Slight attack on ends of 1 sample, nibbles on ends of 1
	As above (GF 5250, white Hostalen, mol. wt. in 50,000–300,000 range)	8, Strips (exposed edges)	*N.e.*	0·022	0·30	Nibbles on edges of all 8 samples
	As above (GF 5250, black Hostalen, mol. wt. in 50,000–300,000 range)	8, Strips (exposed edges)	*N.e.*	0·011	0·16	Nibbles on edges of all 8 samples
		2, Pipe (uncapped)	*C.l.*	0·014	0·06	Extensive nibbles on both ends of 2 samples
	As above (GF 5750, white Hostalen, mol. wt. in 50,000–300,000 range)	8, Strips (exposed edges)	*N.e.*	0·019	0·28	Nibbles on edges of all 8 samples
		2, Pipe (uncapped)	*C.l.*	0·042	0·18	Slight attack on one end of 1 sample, nibbles on remaining ends
		2, Pipe (uncapped)	*C.a.*	0·041	0·22	Slight attack on ends of 1 sample, nibbles on ends of 1
	As above (GF 5750, black Hostalen, mol. wt. in 50,000–300,000 range)	8, Strips (exposed edges)	*N.e.*	0·007	0·12	Nibbles on edges of all 8 samples
		2, Pipe (uncapped)	*C.l.*	0·034	0·15	Slight attack on one end of 1 sample, nibbles on remaining ends
	As above (GM 5010, black Hostalen, mol. wt. c. 300,000)	8, Strips (exposed edges)	*N.e.*	0·012	0·18	Nibbles on edges of all 8 samples
	As above (GM 5050, white Hostalen, mol. wt. c. 300,000)	2, Pipe (uncapped)	*C.l.*	0·033	0·15	Slight attack on one end of 1 sample, nibbles on remaining ends
		2, Pipe (uncapped)	*C.a.*	0·006	0·04	Nibbles on both ends of 2 samples
5	Polyethylene sheet 0·0625 in. thick, high density, 0·95 (Bakelite DGD 4100 Natural)	6, Exposed edges	*N.e.*	0·006	0·18	Nibbles on all 6 samples
		8, Exposed edges	*C.l.*	0·066	1·40	Five samples slightly attacked, nibbles on 3
	As above, high density, 0·95 (Marlex XBP3–73 Natural)	6, Exposed edges	*N.e.*	0·008	0·25	Nibbles on all 6 samples
		8, Exposed edges	*C.l.*	0·069	1·65	Seven samples slightly attacked, extensive nibbles on 1
	As above, high density, 0·95 (Marlex TR201 Natural)	6, Exposed edges	*N.e.*	0·004	0·12	Nibbles on all 6 samples (slight on 3)
		8, Exposed edges	*C.l.*	0·048	0·95	Four samples slightly attacked, nibbles on 4 (extensive on 2)
	As above, high density, 0·95 (Rigidex Type 3 Natural)	6, Exposed edges	*N.e.*	0·002	0·07	Traces of nibbles on all 6 samples
		8, Exposed edges	*C.l.*	0·061	1·35	Seven samples slightly attacked, nibbles on 1
	As above, high density, 0·95 (Rigidex Type 3 Black)	6, Exposed edges	*N.e.*	0·006	0·15	Nibbles on 3 samples
		8, Exposed edges	*C.l.*	0·076	1·50	Eight samples slightly attacked
	Polyethylene sheet 0·0625 in. thick, low density, 0·919, melt flow index 0·2	6, Exposed edges	*N.e.*	0·010	0·26	Nibbles on all 6 samples
		8, Exposed edges	*C.l.*	0·115	2·05	One sample attacked, 7 slightly attacked
	As above, low density, 0·919, melt flow index 2·0	6, Exposed edges	*N.e.*	0·016	0·38	Nibbles on all 6 samples
		8, Exposed edges	*C.l.*	0·181	3·20	Five samples attacked, 2 slightly attacked, nibbles on 1
	As above, low density, 0·923, melt flow index 2·0	6, Exposed edges	*N.e.*	0·015	0·35	Nibbles on all 6 samples
		8, Exposed edges	*C.l.*	0·100	1·67	Seven samples slightly attacked, nibbles on 1
	As above, low density, 0·927, melt flow index 0·5	6, Exposed edges	*N.e.*	0·011	0·27	Nibbles on all 6 samples
		8, Exposed edges	*C.l.*	0·160	2·96	Seven samples slightly attacked, nibbles on 1
6	Polyethylene, primary cable insulation, cross-linked with di-cumyl peroxide (approx. 0·125 in. thick)	8, Exposed edges	*N.e.*	0·010	0·07	Few nibbles, only on edges
		8, Masked edges	*N.e.*	*	*	No visible attack
		8, Exposed edges	*C.l.*	0·030	0·25	Slight attack on 2 samples, nibbles on edges of 6 (on faces of 3)
		8, Masked edges	*C.l.*	0·025	0·20	Nibbles on faces of 8 samples
		8, Exposed edges	*C.a.*	0·26	2·10	Slight attack on 8 samples
		8, Masked edges	*C.a.*	0·125	0·95	Three samples attacked, 4 slightly attacked (holes through 3 samples)

* No measurable weight loss.

TABLE 6

LABORATORY TESTS OF EFFECT OF VARIOUS ADDITIVES ON TERMITE RESISTANCE OF PLASTICS

N.e., Nasutitermes exitiosus; C.l., Coptotermes lacteus; C.a., Coptotermes acinaciformis

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Toxicity	Remarks
		Polyvinyl Chloride					
1	Corvic D65 2, white lead stabilized, D.O.P. plasticized – 0·2% termite repellant 1368 (chlorinated aryl sulphonamide) 0·0625 in. thick	8, Exposed edges	*N.e.*	0·20	1·6	V. slight	Extensive nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·62	5·05	None	Extensive nibbles on edges of all samples
	As above – 0·5% termite repellant 1368	8, Exposed edges	*N.e.*	0·16	1·2	V. slight	Extensive nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·41	1·95	None	Nibbles on edges and faces of all samples
	As above – 1% termite repellant 1368	8, Exposed edges	*N.e.*	0·11	0·9	V. slight	Nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·19	1·55	V. slight	Nibbles on edges and faces of all samples
	As above – 2% termite repellant 1368	8, Exposed edges	*N.e.*	0·09	0·7	V. slight	Patches of nibbles on edges of all samples
		8, Exposed edges	*C.l.*	0·11	0·9	Slight	Occasional nibbles, mainly on edges of samples
2	Corvic D65 8, D.O.P. plasticized, untreated (0·5 in. thick)	6, Exposed edges	*N.e.*	0·24	0·4	Slight	Patches of nibbles on edges of all samples
		6, Exposed edges	*C.l.*	0·77	1·2	None	Slight attack on edges and faces of all samples
	As above – 0·2% Xylamon GI (chlorinated naphthalene)	6, Exposed edges	*N.e.*	0·15	0·3	Slight	Small patches of nibbles on edges of all samples
		6, Exposed edges	*C.l.*	0·25	0·4	V. slight	Slight attack on all samples, mainly from edges
	As above – 0·5% Xylamon GI	6, Exposed edges	*N.e.*	0·14	0·3	Slight	Small patches of nibbles on edges of all samples
		6, Exposed edges	*C.l.*	0·19	0·4	Slight	Extensive nibbles or slight attack on all samples
	As above – 1% Xylamon GI	6, Exposed edges	*N.e.*	0·11	0·2	Slight	Few nibbles, mainly on edges of 2 samples only
		6, Exposed edges	*C.l.*	0·12	0·3	Slight	Small areas of nibbles, mainly on edges of samples
	As above – 2% Xylamon GI	6, Exposed edges	*N.e.*	0·14	0·3	Slight	Few nibbles on edges of all samples
		6, Exposed edges	*C.l.*	0·11	0·2	Medium	Few small areas of nibbles, mainly on edges of samples
3	Cable sheathing, untreated (0·125 in. diam.)	8, Wax-sealed ends	*N.e.*	*	*	Slight	Three samples with conductor exposed, 1 with nibbles, 4 sound
		8, Wax-sealed ends	*C.l.*	*	*	None	Three samples with nibbles, 5 sound
	As above – 0·1% dieldrin	8, Wax-sealed ends	*N.e.*	*	*	Slight	Two samples with conductor exposed, 1 with nibbles, 5 sound
		8, Wax-sealed ends	*C.l.*	*	*	None	One sample with nibbles, 7 sound
	As above – 0·25% dieldrin	8, Wax-sealed ends	*N.e.*	*	*	Slight	One sample with conductor exposed, 1 with nibbles, 6 sound
		8, Wax-sealed ends	*C.l.*	*	*	None	One sample with nibbles, 7 sound
	As above – 0·5% dieldrin	8, Wax-sealed ends	*N.e.*	*	*	Medium	One sample with nibbles, 7 sound
		8, Wax-sealed ends	*C.l.*	*	*	V. slight	One sample with nibbles, 7 sound
	As above – 1% dieldrin	8, Wax-sealed ends	*N.e.*	*	*	Medium	One sample with nibbles, 7 sound
		8, Wax-sealed ends	*C.l.*	*	*	V. slight	All samples sound
	As above – 2% dieldrin	8, Wax-sealed ends	*N.e.*	*	*	High	All samples sound
		8, Wax-sealed ends	*C.l.*	*	*	High	All samples sound
	As above – 3% dieldrin	8, Wax-sealed ends	*N.e.*	*	*	High	All samples sound
		8, Wax-sealed ends	*C.l.*	*	*	High	All samples sound
	As above – 4% dieldrin	8, Wax-sealed ends	*N.e.*	*	*	High	All samples sound
		8, Wax-sealed ends	*C.l.*	*	*	High	All samples sound
	As above – 6% dieldrin	8, Wax-sealed ends	*N.e.*	*	*	High	All samples sound
		8, Wax-sealed ends	*C.l.*	*	*	High	All samples sound

4	PVC cable sheath – 0·2% dieldrin (0·25 in. diam.)	8, Wax-sealed ends	*N.e.*	*	*	V. slight	No visible attack
		8, Wax-sealed ends	*C.I.*	*	*	Slight	No visible attack
	PVC cable sheath – 0·31% aldrin (0·25 in. diam.)	8, Wax-sealed ends	*N.e.*	*	*	Medium	No visible attack
		8, Wax-sealed ends	*C.I.*	*	*	High	No visible attack
	PVC cable sheath – 1% DDT (0·25 in. diam.)	8, Wax-sealed ends	*N.e.*	*	*	None	No visible attack
		8, Wax-sealed ends	*C.I.*	0·25	0·75	None	Two samples with conductor exposed, 4 with nibbles, 2 sound
	PVC cable sheath – 1% arsenious oxide (0·25 in. diam.)	8, Wax-sealed ends	*N.e.*	0·08	0·24	None	Two samples with small areas of nibbles
		8, Wax-sealed ends	*C.I.*	0·20	0·63	None	Five samples with conductor exposed, 3 with nibbles only
5	Corvic D65/2 film, 0·04 in. thick, untreated	8, Film wrapped around timber	*N.e.*	*	*	Slight	Up to 20% of film destroyed
		samples	*C.I.*	*	*	Medium	Film penetrated in several places
	As above – 0·5% aldrin	8, Film wrapped around timber	*N.e.*	*	*	High	Less than 1% of film destroyed
		samples	*C.I.*	*	*	High	Film penetrated in several places
6A	PVC, white-lead stabilized and dioctyl phthalate-plasticized, untreated and unaged (0·0625 in. sheet)	8, Exposed edges	*N.e.*	0·37	4·6	None	Extensive nibbles on edges of all samples
		8, Exposed edges	*C.I.*	0·17	2·1	None	Patches of nibbles along edges of all samples
	As above – 0·2% dieldrin	8, Exposed edges	*N.e.*	0·01	0·2	Medium	Small patches of nibbles on edges of samples
		8, Exposed edges	*C.I.*	0·03	0·4	None	Nibbles on edges of 7 samples, 1 sound
	As above – 0·2% aldrin	8, Exposed edges	*N.e.*	0·06	0·7	Medium	Three samples with edge nibbles, 5 sound
		8, Exposed edges	*C.I.*	*	*	High	Seven samples with few edge nibbles, 1 sound
	As above – 2% Nibren Wax (chlorinated naphthalene)	8, Exposed edges	*N.e.*	0·20	2·0	V. slight	Extensive nibbles on edges of all samples
		8, Exposed edges	*C.I.*	0·13	1·2	None	Extensive nibbles on edges of all samples
	As above – 0·2% lindane	8, Exposed edges	*N.e.*	0·05	0·6	None	Nibbles on edges of all samples
		8, Exposed edges	*C.I.*	0·04	0·5	None	Patches of nibbles on edges of all samples
	As above – 0·2% Z.A.C. (dimethyl dithiocarbamate–cyclohexylamine complex)	8, Exposed edges	*N.e.*	0·16	2·0	None	Extensive nibbles on edges of all samples
		8, Exposed edges	*C.I.*	0·01	0·2	None	Patches of nibbles on edges of all samples
	As above – 2% See Kay Wax (chlorinated naphthalene)	8, Exposed edges	*N.e.*	0·12	1·3	Slight	Extensive nibbles on edges of all samples
		8, Exposed edges	*C.I.*	0·05	0·6	None	Nibbles on edges of all samples
6B	PVC, white-lead stabilized, dioctyl phthalate-plasticized, untreated, artificially aged (0·0625 in. sheet)	4, Exposed edges	*N.e.*	0·31	5·7	?V. slight	All samples slightly attacked to attacked
		4, Exposed edges	*C.I.*	0·44	8·1	None	All samples slightly attacked to attacked
	As above – 0·2% dieldrin	4, Exposed edges	*N.e.*	0·08	1·3	?V. slight	Edge nibbles, isolated small areas of slight attack
		4, Exposed edges	*C.I.*	0·05	0·8	None	Edge nibbles, isolated small areas of slight attack
	As above – 0·2% aldrin	4, Exposed edges	*N.e.*	0·09	1·6	None	Edge nibbles, isolated small areas of slight attack
		4, Exposed edges	*C.I.*	0·08	1·2	None	Edge nibbles, isolated small areas of slight attack
	As above – 2% Nibren Wax	4, Exposed edges	*N.e.*	0·28	4·3	?V. slight	All samples slightly attacked to attacked
		4, Exposed edges	*C.I.*	0·50	7·4	None	All samples slightly attacked to attacked
	As above – 0·2% lindane	4, Exposed edges	*N.e.*	0·29	5·1	None	All samples slightly attacked to attacked
		4, Exposed edges	*C.I.*	0·41	6·8	None	All samples slightly attacked to attacked
	As above – 0·2% Z.A.C.	4, Exposed edges	*N.e.*	0·29	5·6	?V. slight	All samples slightly attacked to attacked
		4, Exposed edges	*C.I.*	0·48	9·0	None	All samples slightly attacked to attacked
	As above – 2% See Kay Wax	4, Exposed edges	*N.e.*	0·27	4·0	None	All samples slightly attacked to attacked
		4, Exposed edges	*C.I.*	0·42	6·2	None	All samples slightly attacked to attacked
7	Corvic D65/2 plasticized with D.O.P., untreated (0·0625 in. sheet), four types of surface finish	32, Exposed edges	*N.e.*	0·10	1·4	None	Damage ranging from extensive nibbles to slight attack
		32, Exposed edges	*C.I.*	0·57	7·5	None	Damage ranging from slightly to badly attacked
	As above – 0·2% dieldrin, four types of surface finish	32, Exposed edges	*N.e.*	0·04	0·5	None	Nibbles only along edges of samples
		32, Exposed edges	*C.I.*	0·04	0·5	None	Three samples slightly attacked, nibbles on most others

Table 6 (*Continued*)

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Toxicity	Remarks
		Polystyrene					
8	Expanded polystyrene, untreated (1·5 in. thick)	24, Exposed edges	*N.e.*	*	*	None	Most samples slightly attacked
		24, Exposed edges	*C.l.*	*	*	None	All samples badly attacked or destroyed
	As above + 1% dieldrin	24, Exposed edges	*N.e.*	*	*	V. slight	Less than 50% of samples showing slight attack
		24, Exposed edges	*C.l.*	*	*	None	All samples slightly attacked to attacked
		Polyethylene					
9	Grade 20, cable sheath, untreated	8, Uncapped	*N.e.*	0·02	0·06	None	Small isolated areas of attack on 3 samples
		8, Uncapped	*C.l.*	*	*	None	Few small areas of attack only
		8, Uncapped	*C.a.*	0·69	3·1	None	Penetration to conductor in all samples
	As above + lead naphthenate	8, Uncapped	*N.e.*	*	*	None	No visible attack
		8, Uncapped	*C.l.*	*	*	None	Isolated areas of surface nibbles
		8, Uncapped	*C.a.*	0·55	2·7	None	Penetration to conductor in all samples
10	Sheet, 0·0625 in. thick (DFDL–6015 0·3 melt index, 0·92 density base resin – 2·5% carbon black)	8, Exposed edges	*N.e.*	0·011	0·18	None	Nibbles on edges of 8 samples
		8, Masked edges	*N.e.*	*	*	None	No visible attack
		8, Exposed edges	*C.l.*	0·230	3·10	V. slight	Slight attack on all samples from edges
		8, Masked edges	*C.l.*	0·141	1·30	V. slight	Nibbles on faces (and edges) of all samples
		4, Exposed edges	*C.a.*	0·382	10·30	None	Attack on 1 sample, slight attack on 3
		4, Masked edges	*C.a.*	0·156	3·14	None	Slight attack on 1 sample, nibbles on 2
	As above – 0·2% Sevin	4, Exposed edges	*N.e.*	*	*	None	Few nibbles on edges of 2 samples
		4, Masked edges	*N.e.*	*	*	None	No visible attack
		8, Exposed edges	*C.l.*	0·081	1·15	Slight	Slight attack on edges of 5 samples, nibbles on 3
		8, Masked edges	*C.l.*	0·045	0·45	Slight	Slight attack on end of 1 sample, 7 sound
		4, Exposed edges	*C.a.*	0·180	5·01	V. slight	Slight attack on 6 samples
		4, Masked edges	*C.a.*	*	*	V. slight	No visible attack
	As above – 0·5% Sevin	4, Exposed edges	*N.e.*	*	*	None	Few nibbles on edges of 1 sample
		4, Masked edges	*N.e.*	*	*	None	No visible attack
		8, Exposed edges	*C.l.*	0·016	0·25	Slight	Nibbles on edges of 6 samples
		8, Masked edges	*C.l.*	*	*	Slight	No visible attack
		4, Exposed edges	*C.a.*	0·035	1·00	Slight	Slight attack on 2 samples, nibbles on 2
		4, Masked edges	*C.a.*	*	*	Slight	No visible attack
	As above + 1% Sevin	4, Exposed edges	*N.e.*	*	*	None	Few nibbles on edge of 1 sample
		4, Masked edges	*N.e.*	*	*	None	No visible attack
		8, Exposed edges	*C.l.*	0·013	0·20	Slight	Nibbles on edges of 7 samples
		8, Masked edges	*C.l.*	*	*	V. slight	No visible attack
		4, Exposed edges	*C.a.*	0·012	0·27	Medium	Nibbles on edges of all samples
		4, Masked edges	*C.a.*	*	*	Medium	No visible attack
11	Pipe, 1 in. I.D., untreated	2, Uncapped ends	*C.a.*	0·123	0·69	Slight	Slight attack on ends of samples
		2, Capped ends	*C.a.*	0·02	0·12	Slight	Two patches of nibbles on pipe walls
	As above + 1% Sevin	2, Uncapped ends	*C.a.*	*	*	Medium	No visible attack
		2, Capped ends	*C.a.*	*	*	Medium	No visible attack

12	Pipe. 0·75-in. bore. 0·060-in. wall thickness. (Alkathene D140 21 black 902, melt flow index 0·25, density 0·934)	2, Uncapped ends	*N.e.*	0·016	0·15	None	Nibbles on end of 1 sample
		2 Capped ends	*N.e.*	*	*	None	No visible attack
		2, Uncapped ends	*C.l.*	0·028	0·30	None	Nibbles on both ends of 2 samples
		2, Capped ends	*C.l.*	*	*	None	No visible attack
		2, Uncapped ends	*C.a.*	0·225	2·60	None	Attack on ends of 2 samples (holes through walls of both)
		2, Capped ends	*C.a.*	0·092	1·05	None	Attack on walls of 2 samples (extensive)
	As above + 0·05% lindane	2, Uncapped ends	*N.e.*	*	*	None	No visible attack
		2, Capped ends	*N.e.*	*	*	None	No visible attack
		2, Uncapped ends	*C.l.*	0·010	0·10	None	Nibbles on end of 1 sample
		2, Capped ends	*C.l.*	*	*	None	No visible attack
		2, Uncapped ends	*C.a.*	0·018	0·20	None	Few nibbles on ends of 2 samples
		2, Capped ends	*C.a.*	*	*	None	No visible attack
	As above + 0·1% lindane	2, Uncapped ends	*N.e.*	*	*	None	No visible attack
		2, Capped ends	*N.e.*	*	*	None	No visible attack
		2, Uncapped ends	*C.l.*	0·021	0·25	None	Nibbles on ends of 2 samples
		2, Capped ends	*C.l.*	*	*	None	No visible attack
		2, Uncapped ends	*C.a.*	0·018	0·20	None	Few nibbles on ends of 2 samples
		2, Capped ends	*C.a.*	*	*	None	No visible attack
	As above + 0·2% lindane	2, Uncapped ends	*N.e.*	*	*	None	No visible attack
		2, Capped ends	*N.e.*	*	*	None	No visible attack
		2, Uncapped ends	*C.l.*	0·024	0·30	None	Nibbles on ends of 2 samples
		2, Capped ends	*C.l.*	*	*	None	No visible attack
		2, Uncapped ends	*C.a.*	0·022	0·30	None	Nibbles on ends of 1 sample only
		2, Capped ends	*C.a.*	*	*	None	No visible attack
	As above + 0·05% Gammexane	2, Uncapped ends	*N.e.*	*	*	None	No visible attack
		2, Capped ends	*N.e.*	*	*	None	No visible attack
		2, Uncapped ends	*C.l.*	0·023	0·25	None	Nibbles on ends of 2 samples
		2, Capped ends	*C.l.*	*	*	None	No visible attack
		2, Uncapped ends	*C.a.*	0·064	0·70	None	Attack on end of 1 sample, pipe wall holed in 1 sample
		2, Capped ends	*C.a.*	*	*	None	No visible attack
	As above + 0·1% Gammexane	2, Uncapped ends	*N.e.*	0·007	0·10	None	Nibbles on end of 1 sample
		2, Capped ends	*N.e.*	*	*	None	No visible attack
		2, Uncapped ends	*C.l.*	0·030	0·35	None	Slight attack on end of 1 sample, nibbles on 1
		2, Capped ends	*C.l.*	*	*	None	No visible attack
		2, Uncapped ends	*C.a.*	0·052	0·60	None	Attack on end of 1 sample, slight attack on end of 1
		2, Capped ends	*C.a.*	*	*	None	No visible attack
	As above + 0·2% Gammexane	2, Uncapped ends	*N.e.*	*	*	None	No visible attack
		2, Capped ends	*N.e.*	*	*	None	No visible attack
		2, Uncapped ends	*C.l.*	0·021	0·20	None	Nibbles on ends of 2 samples
		2, Capped ends	*C.l.*	*	*	None	No visible attack
		2, Uncapped ends	*C.a.*	0·024	0·30	None	Nibbles on ends of 2 samples
		2, Capped ends	*C.a.*	*	*	None	No visible attack

TABLE 6 (*Continued*)

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Toxicity	Remarks
			Polyurethane				
13	Sheet, 0·5 in. thick (polyester-prepolymer-based foam, 2–3 lb cu ft density), untreated	8, Exposed edges	*N.e.*	0·105	4·75	Medium	Eight samples attacked
		8, Exposed edges	*C.l.*	0·350	16·55	Medium	Six samples badly attacked, 2 attacked
	As above — 1% chlordane by weight	8, Exposed edges	*N.e.*	0·113	4·80	Medium	Two samples badly attacked, 4 attacked, 2 slightly attacked
		8, Exposed edges	*C.l.*	0·190	7·95	Medium	Six samples attacked, 2 slightly attacked
	As above — 0·5% dieldrin by weight	8, Exposed edges	*N.e.*	0·092	3·75	Medium	Four samples badly attacked, 2 attacked, 2 slightly attacked
		8, Exposed edges	*C.l.*	0·212	8·85	Medium	Six samples attacked, 2 slightly attacked
	As above — 0·5% aldrin by weight	8, Exposed edges	*N.e.*	0·117	5·35	Medium	Four samples attacked, 4 slightly attacked
		8, Exposed edges	*C.l.*	0·135	6·25	Medium	Two samples attacked, 6 slightly attacked
	As above — 0·06% arsenic pentoxide by weight	8, Exposed edges	*N.e.*	0·125	5·00	Medium	Six samples attacked, 2 slightly attacked
		8, Exposed edges	*C.l.*	0·158	6·45	High	Six samples slightly attacked, 2 attacked
	As above — 1·0% phenyl mercuric complex by weight	8, Exposed edges	*N.e.*	0·158	6·45	Medium	Eight samples attacked
		8, Exposed edges	*C.l.*	0·270	12·90	Medium	Two samples badly attacked, 4 attacked, 2 slightly attacked
	As above — 2·5% phenyl mercuric complex by weight	8, Exposed edges	*N.e.*	0·250	10·85	Medium	Eight samples attacked
		8, Exposed edges	*C.l.*	0·403	16·95	Medium	Four samples badly attacked, 4 attacked
14	Foam (polyester-prepolymer-based, 2–3 lb cu ft density) 0·5-in.-square strips, untreated	8, Exposed edges	*N.e.*	0·505	26·60	Slight	Seven samples badly attacked, 1 attacked
		8, Exposed edges	*C.l.*	0·557	28·30	Medium	Eight samples attacked
		8, Exposed edges	*C.a.*	0·847	43·60	Medium	Eight samples badly attacked
	As above — 0·5% aldrin by weight	8, Exposed edges	*N.e.*	0·427	20·45	Slight	One sample badly attacked, 2 attacked, 5 slightly attacked
		8, Exposed edges	*C.l.*	0·736	40·50	Medium	Eight samples badly attacked
		8, Exposed edges	*C.a.*	0·891	35·00	Medium	Three samples badly attacked, 5 attacked
	As above — 1·0% aldrin by weight	8, Exposed edges	*N.e.*	0·291	17·15	Slight	Eight samples attacked
		8, Exposed edges	*C.l.*	0·610	27·90	Medium	One sample badly attacked, 7 attacked
		8, Exposed edges	*C.a.*	0·815	35·10	Medium	Six samples badly attacked, 2 attacked
	As above — 5·0% aldrin by weight	8, Exposed edges	*N.e.*	0·321	16·00	Slight	Seven samples attacked, 1 slightly attacked
		8, Exposed edges	*C.l.*	0·361	17·15	Medium	Eight samples slightly attacked
		8, Exposed edges	*C.a.*	0·410	18·20	Medium	Three samples attacked, 5 slightly attacked
	As above — 0·5% dieldrin by weight	8, Exposed edges	*N.e.*	0·483	28·10	Slight	Seven samples badly attacked, 1 attacked
		8, Exposed edges	*C.l.*	0·700	37·70	Medium	Eight samples attacked to badly attacked
		8, Exposed edges	*C.a.*	0·717	37·80	Medium	Five samples badly attacked, 3 attacked
	As above — 1·0% dieldrin by weight	8, Exposed edges	*N.e.*	0·453	26·30	Slight	Seven samples badly attacked, 1 attacked
		8, Exposed edges	*C.l.*	0·698	40·65	Medium	Eight samples attacked to badly attacked
		8, Exposed edges	*C.a.*	0·712	38·15	Medium	Six samples badly attacked, 2 attacked
	As above — 5·0% dieldrin by weight	8, Exposed edges	*N.e.*	0·384	19·40	Slight	Two samples badly attacked, 6 attacked
		8, Exposed edges	*C.l.*	0·441	20·00	Medium	Three samples attacked, 5 slightly attacked
		8, Exposed edges	*C.a.*	0·793	32·85	Medium	One sample badly attacked, 4 attacked, 3 slightly attacked

15	Elastomer, hand cast 0·5-in. sheet, untreated	8. Exposed edges	*N.e.*	0·140	0·15	None	Nibbles on 8 samples
		8. Exposed edges	*C.l.*	0·101	0·12	None	Slight attack on 5 samples, nibbles on 3
		8. Exposed edges	*C.a.*	0·267	0·35	None	Slight attack on 6 samples, nibbles on 2
	As above — 1% chlordane by weight	8. Exposed edges	*N.e.*	*	*	High	A few nibbles on 1 sample
		8. Exposed edges	*C.l.*	*	*	High	No visible attack
		8. Exposed edges	*C.a.*	*	*	High	No visible attack
	As above — 0·25% dieldrin by weight	8. Exposed edges	*N.e.*	*	*	Medium	No visible attack
		8. Exposed edges	*C.l.*	*	*	Medium	No visible attack
		8. Exposed edges	*C.a.*	*	*	Medium	No visible attack
	As above — 0·06% arsenic pentoxide by weight	8. Exposed edges	*N.e.*	0·213	0·27	None	Nibbles on edges of 8 samples
		8. Exposed edges	*C.l.*	0·245	0·33	None	Slight attack on 4 samples, nibbles on 4
		8. Exposed edges	*C.a.*	0·346	0·46	None	Slight attack on 7 samples, nibbles on 1

* No measurable weight loss.

complete protection. No toxic action toward *N. exitiosus* could be demonstrated, but *C. lacteus* is affected progressively as the concentration of Xylamon GI rises.

In Test No. 3 (Table 6) this formulation of polyvinyl chloride is somewhat more susceptible to *N. exitiosus* than *C. lacteus* in the untreated condition. The addition of dieldrin reduces susceptibility to attack progressively with increasing concentration up to the 2 % level, at which complete protection is obtained. In the same way, toxicity to both species of termites increases up to the 2 % level, beyond which no added activity occurs.

The polyvinyl chloride cable sheaths in Test No. 4 (Table 6) were supplied by three different manufacturers, so there may well be intrinsic differences in the natural resistance of the base mixes. Sheaths containing 0·2 % dieldrin, 0·31 % aldrin, or 1 % DDT are immune to attack by *N. exitiosus*, but only the first two of these treatments are effective against *C. lacteus*. Both the dieldrin and aldrin treatments are obviously toxic to the two species of termites.

In Test No. 5 (Table 6) polyvinyl chloride film shows definite evidence of improved resistance to attack by *N. exitiosus* after the incorporation of 0·5 % aldrin. There is no appreciable improvement in its resistance to *C. lacteus* attack, but the treated film is considerably more toxic to both termites.

Test No. 6 (Table 6) consists of two parts, A and B, the first of which was made with samples recently processed and the second with samples subjected to an artificial ageing process. This process consisted essentially of exposing the samples to a constant-speed air stream at 82 ± 1 °C, for a period of 6 weeks.

In the tests of unaged polyvinyl chloride, all the treated samples have a higher termite resistance than the untreated material, the 0·2 % aldrin, dieldrin, and lindane treatments being somewhat superior to the others.

After artificial ageing, the only treatments that are obviously better than the untreated controls are 0·2 % aldrin and 0·2 % dieldrin, both of which continue to give a high level of protection (Fig. 4). The effectiveness of the remaining four treatments has been destroyed by the accelerated ageing process.

In Test No. 7 (Table 6) the weight loss figures represent the average values of eight separate readings (duplicate tests of four different surface finishes) for both untreated and treated material. The addition of 0·2 % dieldrin to polyvinyl chloride reduces the amount of termite attack, especially that of *C. lacteus*, but does not give complete immunity. In this test, as in the previous one, there is no indication of toxic action resulting from the addition of dieldrin.

In Test No. 8 (Table 6) the results are a summary of six readings on both untreated and dieldrin-treated expanded polystyrene. The cellular and friable nature of this material made it impossible to remove all termite plastering effectively, so that no reliable weight loss figures could be obtained although all samples showed obvious damage. The untreated material is susceptible to termite attack, especially by *C. lacteus*, but the addition of 1 % by weight of dieldrin decreases this susceptibility appreciably. There is very little evidence of toxic action, however, and this, together with the failure of the treatment to give anything approaching complete protection, strongly suggests that the actual retention of dieldrin is very much less than the stated figure of 1 % by weight.

Several tests were made with insecticidal additives to polyethylene. In Test No. 9 (Table 6), polyethylene cable sheath, untreated and treated with an unspecified amount

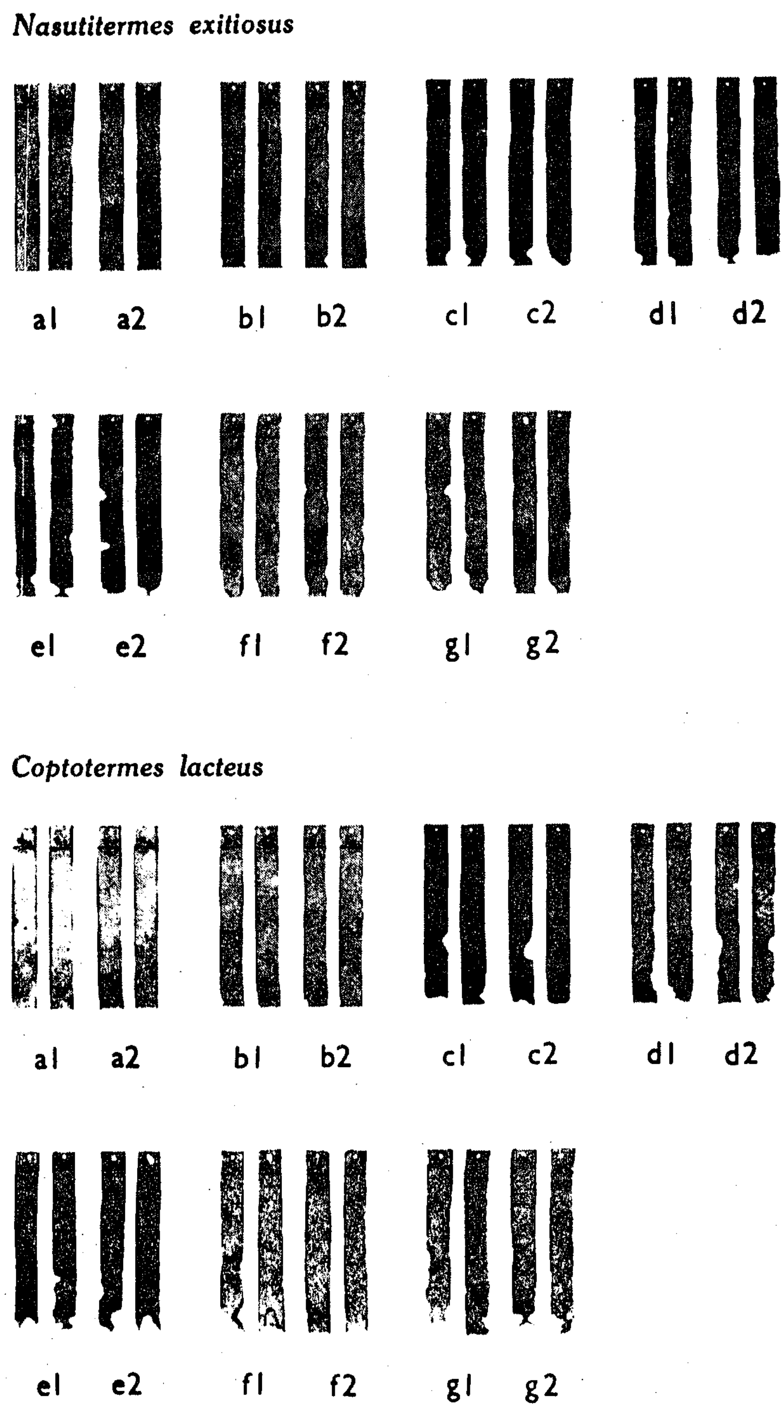


Fig. 4. Samples of polyvinyl chloride containing various insecticides tested for termite resistance after artificial ageing. (a1, a2) 0·2% dieldrin; (b1, b2) 0·2% aldrin; (c1, c2) 2·0% Nibren Wax; (d1, d2) 0·2% lindane; (e1, e2) 0·2% Z.A.C.; (f1, f2) 2·0% See Kay Wax; (g1, g2) untreated.

of lead naphthenate, was subjected to the attack of three different species of termites. The results obtained with *N. exitiosus* and *C. lacteus* are inconclusive, but the *C. acinaciformis* test shows very clearly that this termite is quite unaffected by the addition of lead naphthenate.

The effect of increasing additions of Sevin (1-naphthyl *N*-methyl carbamate) to low-density polyethylene is shown in Test No. 10 (Table 6). There is a progressive reduction in attack as the level of Sevin rises, and this is particularly evident in the *C. acinaciformis* colonies in which the level of attack drops from about 10% for fully exposed untreated samples to about 0·25% for similar samples containing 0·5% Sevin. A further point of interest is that the treatment exhibits only a slight to medium toxic effect on *Coptotermes* spp., and none at all on *N. exitiosus*.

In a further test of Sevin (Test No. 11, Table 6) the results confirm the effectiveness of a 1% addition in producing immunity to termite attack.

Test No. 12 (Table 6) gives details of the effects of progressive additions of lindane and Gammexane on the termite resistance of a medium-density polyethylene. It may be seen that the untreated polymer is most severely damaged by *C. acinaciformis*, and that the damage is effectively reduced by all levels of lindane, and by the highest level of Gammexane (0·2%). The last fact infers that protection is related to the content of γ-isomer, in this case about 0·025%, and that this is the minimum loading that can be expected to give a high level of protection. It should be noted that none of the treatments was toxic to any of the three species of termites, and this suggests that the protective action is due to repellent or deterrent properties. Such properties are frequently associated with chemicals with a relatively high vapour pressure, so that gradual loss through volatilization could reduce the effectiveness of treatment.

Three tests were made with insecticidal additives in polyurethane. In Test No. 12 (Table 6), a foam based on polyester prepolymer, which was readily attacked in the untreated condition by both *N. exitiosus* and *C. lacteus*, was not protected by any of five chemicals, all known to be effective termite toxicants. It is possible that these chemicals may have been partly, or wholly, inactivated during the processing of the foam. This view was supported by the results of Test No. 13 (Table 6), in which two of the chemicals concerned, aldrin and dieldrin, even when used at 10 times the concentration in Test No. 12, failed to protect the polyester prepolymer foam against attack. Furthermore, in both these tests, the toxicity of treated foams to the termites was no different from that of the untreated foam.

In Test No. 14 (Table 6) not only was a polyurethane elastomer completely protected from termite attack by additions of chlordane or dieldrin which proved completely inadequate in Test No. 12, but the treatments also exhibited a medium to high toxicity to the termites.

The evidence of the above three tests leaves little doubt that the processes involved in producing polyurethane foams effectively inactivate insecticidal additives such as aldrin, dieldrin, and chlordane.

A general review of the results of this series of tests of insecticidal additives shows that the only compounds tested which gave a high level of protection were aldrin and dieldrin, with both lindane and Sevin showing some promise. Furthermore, the first two compounds when incorporated in plastic proved to be highly resistant to an accelerated ageing process. For these reasons, aldrin and dieldrin would appear to be

the most logical insecticides for the termite-proofing of plastics. Further work is still required, however, to determine the most satisfactory methods of incorporating all of these compounds in order to ensure efficient retention, and to overcome the problem of the inactivation of insecticidal additives incorporated in foams.

(*e*) *Incorporation of Inert Fillers*

The desirability of termite-proofing plastics by the incorporation of compounds such as aldrin and dieldrin may be open to question because of possible hazards involved. For instance, it is doubtful whether plastic piping incorporating either of these compounds would be acceptable to public health authorities or to customers themselves for use in domestic water supplies. To give another example, the repeated handling of treated cable sheathing by technicians could conceivably result in the absorption of toxic amounts of insecticide through the skin, especially as insecticides tend to bloom out on the surface of some plastics. Although these hazards may very well be negligible, it seems desirable to look for alternative means of producing a satisfactory level of termite resistance in normally susceptible plastics by methods other than the incorporation of insecticides that are toxic to man.

By means of simple scratch tests carried out under a binocular microscope (Bailey 1954), using termite worker mandibles cemented to the tips of dissecting needles, it has been possible to show that all the plastic materials listed in Table 1 have an intrinsic hardness less than that of termite mandibles. Although scratching occurred most readily on obviously soft and non-rigid plastics and was increasingly difficult on semi-rigid and rigid plastics, there is no *a priori* reason why any of these materials should not be scored by mandibular action and ultimately attacked to a greater or lesser extent by termites. The test results show, however, that many of these plastics, particularly the rigid types, do not suffer much damage, but semi-rigid and non-rigid plastics are often extensively damaged. It is concluded from this that the intrinsic hardness of a plastic plays some part in its termite resistance.

There appear to be three ways in which this factor of hardness might be used to reduce the amount of termite damage to plastics in service. The first two are the more widespread use of rigid plastics, and the development of surface-hardening techniques. Both these approaches, however, involve a sacrifice of flexibility and limit the field of application of the end product. The third method, which has very little effect on flexibility and would not limit the applications of the end product, is to improve the "internal hardness" of the plastic by incorporating finely divided mineral particles, preferably using minerals intrinsically harder than termite mandibles.

It is common practice to add either organic or inorganic fillers to plastics, and materials such as mica, china clay, diatomaceous earth, and calcium carbonate are often used for such purposes as improving the electrical properties, heat resistance, or moulded appearance of plastics. Accordingly, a series of tests was made to explore the possibilities of this practice with the broad objective of producing a filled plastic so abrasive to termite mandibles as to discourage attack. The results are summarized in Table 7.

In Test No. 1 (Table 7), various mineral powders ground to pass a 200-mesh sieve were incorporated in non-rigid polyvinyl chloride at the rate of 5% by volume.

TABLE 7

LABORATORY TESTS OF EFFECT OF ADDING INERT FILLERS ON TERMITE RESISTANCE OF PLASTICS

N.e., *Nasutitermes exitiosus*; *C.l.*, *Coptotermes lacteus*; *C.a.*, *Coptotermes acinaciformis*

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. Eaten (g)	Amt. Eaten (%)	Remarks
		Polyvinyl Chloride				
1	Corvic D65/2 polymer, plasticized with 47·5% D.O.P., untreated, 0·0625-in. thick sheet	8, Strips (exposed edges)	*C.l.*	1·92	18·8	All 8 samples badly attacked
	As above – 5% by vol. hard clay	8, Strips (exposed edges)	*C.l.*	3·14	28·2	All 8 samples badly attacked to destroyed
	As above – 5% by vol. barytes	8, Strips (exposed edges)	*C.l.*	0·87	6·7	Six samples slightly attacked, 2 attacked
	As above – 5% by vol. light magnesium carbonate	8, Strips (exposed edges)	*C.l.*	3·00	28·1	Seven samples badly attacked, 1 attacked
	As above – 5% by vol. talc	8, Strips (exposed edges)	*C.l.*	1·56	14·2	Seven samples attacked, 1 slightly attacked
	As above – 5% by vol. Micafine P	8, Strips (exposed edges)	*C.l.*	3·98	33·0	All 8 samples badly attacked
	As above – 5% by vol. water ground whiting	8, Strips (exposed edges)	*C.l.*	1·37	12·7	All 8 samples attacked
	As above – 5% by vol. activated whiting	8, Strips (exposed edges)	*C.l.*	1·43	12·8	Six samples attacked, 2 slightly attacked
	As above – 5% by vol. soft black	8, Strips (exposed edges)	*C.l.*	2·08	17·0	Six samples attacked, 1 badly attacked, 1 slightly attacked
	As above – 5% by vol. furnace black	8, Strips (exposed edges)	*C.l.*	1·90	16·1	Six samples attacked, 2 badly attacked
	As above – 5% by vol. channel black	8, Strips (exposed edges)	*C.l.*	2·11	17·1	Three samples attacked, 5 badly attacked
	As above – 5% by vol. acetylene black	8, Strips (exposed edges)	*C.l.*	1·68	14·7	All 8 samples attacked
	As above – 5% by vol. fine-particle silica (Aerosil)	8, Strips (exposed edges)	*C.l.*	1·54	13·0	Four samples attacked, 4 slightly attacked to attacked
	As above – 5% by vol. powdered glass yarn	8, Strips (exposed edges)	*C.l.*	1·02	10·1	Four samples attacked, 4 slightly attacked to attacked
	As above – 5% hard silica	8, Strips (exposed edges)	*C.l.*	0·39	3·5	All 8 samples slightly attacked
	As above – 5% soft silica	8, Strips (exposed edges)	*C.l.*	0·69	7·0	Five samples slightly attacked, 3 slightly attacked to attacked
	As above – 5% feldspar	8, Strips (exposed edges)	*C.l.*	0·80	8·3	Five samples attacked, 3 slightly attacked to attacked
	As above – 5% zircon flour	8, Strips (exposed edges)	*C.l.*	0·61	5·2	Seven samples slightly attacked, 1 slightly attacked to attacked

	As above — 5%, calcite	8, Strips (exposed edges)	*C.l.*	1·03	9·2	Six samples attacked, 2 slightly attacked to attacked
	As above — 5%, diatomaceous earth	8, Strips (exposed edges)	*C.l.*	0·61	5·7	Five samples slightly attacked, 3 slightly attacked to attacked
	As above — 5%, South Australian clay	8, Strips (exposed edges)	*C.l.*	2·87	27·7	All 8 samples badly attacked
2	PVC (Corvic D65 8 PVC polymer plasticized with D.O.P., 30 parts per 100 total mix) 0·0625 in. thick sheet, no additive, density 1·28, B.S.H. at 26°C 85, B.S.S. at 26°C 28	6, Exposed edges	*N.e.*	0·069	1·19	Two samples slightly attacked, nibbles on 4
		8, Exposed edges	*C.l.*	1·023	12·90	Two samples badly attacked, 3 attacked, 3 slightly attacked
	As above — 5% clay by vol., density 1·35, B.S.H. at 26°C 89, B.S.S. at 26°C 23	6, Exposed edges	*N.e.*	0·071	1·21	Four samples slightly attacked, nibbles on 2
		8, Exposed edges	*C.l.*	2·045	26·85	Eight samples badly attacked
	As above — 10% clay by vol., density 1·42, B.S.H. at 26°C 90, B.S.S. at 26°C 20	6, Exposed edges	*N.e.*	0·100	1·44	One sample attacked, 3 slightly attacked, nibbles on 2
		8, Exposed edges	*C.l.*	2·330	28·15	Eight samples badly attacked
	As above — 20% clay by vol., density 1·57, B.S.H. at 26°C 96, B.S.S. at 26°C 14	6, Exposed edges	*N.e.*	0·230	3·19	Two samples attacked, 4 slightly attacked
		8, Exposed edges	*C.l.*	2·095	22·30	Seven samples badly attacked, 1 slightly attacked
	As above — 40% clay by vol., density 1·85, B.S.H. at 26°C 99, B.S.S. at 26°C 6	6, Exposed edges	*N.e.*	0·167	1·76	Four samples slightly attacked, nibbles on 2
		8, Exposed edges	*C.l.*	0·753	12·15	Two samples badly attacked, 3 attacked, 3 slightly attacked
	As above — 5% whiting by vol., density 1·35, B.S.H. at 26°C 86, B.S.S. at 26°C 27	6, Exposed edges	*N.e.*	0·075	1·20	Two samples slightly attacked, nibbles on 4
		8, Exposed edges	*C.l.*	0·889	10·60	Three samples badly attacked, 5 attacked
	As above — 10% whiting by vol., density 1·41, B.S.H. at 26°C 88, B.S.S. at 26°C 25	6, Exposed edges	*N.e.*	0·084	1·26	One sample attacked, 2 slightly attacked, nibbles on 3
		8, Exposed edges	*C.l.*	0·627	7·10	One sample badly attacked, 5 attacked, 2 slightly attacked
	As above — 20% whiting by vol., density 1·55, B.S.H. at 26°C 91, B.S.S. at 26°C 19	6, Exposed edges	*N.e.*	0·097	1·43	Three samples slightly attacked, nibbles on 3
		8, Exposed edges	*C.l.*	0·788	8·55	Three samples badly attacked, 2 attacked, 3 slightly attacked
	As above — 40% whiting by vol., density 1·81, B.S.H. at 26°C 96, B.S.S. at 26°C 12	6, Exposed edges	*N.e.*	0·208	2·43	Four samples slightly attacked, nibbles on 2
		8, Exposed edges	*C.l.*	0·737	6·50	One sample badly attacked, 3 attacked, 4 slightly attacked
	As above — 5% barytes by vol., density 1·44, B.S.H. at 26°C 88, B.S.S. at 26°C 24	6, Exposed edges	*N.e.*	0·043	0·81	Two samples slightly attacked, nibbles on 4
		8, Exposed edges	*C.l.*	0·444	5·85	Four samples attacked, 4 slightly attacked
	As above — 10% barytes by vol., density 1·60, B.S.H. at 26°C 90, B.S.S. at 26°C 22	6, Exposed edges	*N.e.*	0·034	0·54	One sample slightly attacked, nibbles on 4
		8, Exposed edges	*C.l.*	0·276	3·25	Two samples attacked, 6 slightly attacked
	As above — 20% barytes by vol., density 1·92, B.S.H. at 26°C 92, B.S.S. at 26°C 19	6, Exposed edges	*N.e.*	0·023	0·30	Two samples with nibbles, 4 sound
		8, Exposed edges	*C.l.*	0·260	2·45	One sample attacked, 7 slightly attacked
	As above — 40% barytes by vol., density 2·58, B.S.H. at 26°C 97, B.S.S. at 26°C 11	6, Exposed edges	*N.e.*	0·047	0·47	Six samples with nibbles
		8, Exposed edges	*C.l.*	0·229	1·80	Seven samples slightly attacked, nibbles on 1
	As above — 2·5% silica by vol., density 1·30, B.S.H. at 26°C 97, B.S.S. at 26°C 25	6, Exposed edges	*N.e.*	0·025	0·45	Six samples with nibbles
		8, Exposed edges	*C.l.*	0·350	4·55	Three samples attacked, 5 slightly attacked
	As above — 5% silica by vol., density 1·33, B.S.H. at 26°C 88, B.S.S. at 26°C 24	6, Exposed edges	*N.e.*	0·035	0·65	Two samples slightly attacked, nibbles on 4
		8, Exposed edges	*C.l.*	0·258	3·75	One sample attacked, 7 slightly attacked
	As above — 10% silica by vol., density 1·36, B.S.H. at 26°C 88, B.S.S. at 26°C 24	6, Exposed edges	*N.e.*	0·030	0·41	Six samples with nibbles
		8, Exposed edges	*C.l.*	0·136	1·40	Three samples slightly attacked, extensive nibbles on 5
	As above — 20% silica by vol., density 1·45, B.S.H. at 26°C 92, B.S.S. at 26°C 19	6, Exposed edges	*N.e.*	0·023	0·39	Six samples with nibbles
		8, Exposed edges	*C.l.*	0·103	1·30	Slight attack on 7 samples, nibbles on 1
	As above — 40% silica by vol., density 1·61, B.S.H. at 26°C 97, B.S.S. at 26°C 10	6, Exposed edges	*N.e.*	0·015	0·24	Three samples with nibbles, 3 sound
		8, Exposed edges	*C.l.*	0·057	0·65	Slight attack on 4 samples, nibbles on 4

TABLE 7 (*Continued*)

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. (g)	Eaten (%)	Remarks
		Polyvinyl Chloride (Continued)				
3	Geon 101 EP resin. D.I.O.P. and T.C.P. plasticizers 44 parts/100 parts base resin — 47·5% by wt. calcium carbonate (Omya B.S.H.), 0·0625-in. thick sheet	8, Exposed edges	*N.e.*	1·391	17·85	Eight samples attacked
		8, Exposed edges	*C.l.*	0·507	5·12	Four samples attacked, 4 slightly attacked
		8, Exposed edges	*C.a.*	0·717	8·14	Two samples badly attacked. 4 attacked, nibbles on 2
	As above — 47·5% by wt. crystalline calcium carbonate (Microcalite VK1)	8, Exposed edges	*N.e.*	0·618	5·20	Three samples attacked, 5 slightly attacked
		8, Exposed edges	*C.l.*	0·218	1·75	Two samples attacked, 3 slightly attacked, nibbles on 2
		8, Exposed edges	*C.a.*	0·445	3·55	Two samples attacked, 6 slightly attacked
	As above — 47·5% by wt. ground dolomite (Microdol 1)	8, Exposed edges	*N.e.*	0·252	2·15	Seven samples slightly attacked, nibbles on 1
		8, Exposed edges	*C.l.*	0·161	1·28	One sample slightly attacked, nibbles on 7
		8, Exposed edges	*C.a.*	0·223	1·84	Five samples slightly attacked, nibbles on 3
	As above — 47·5% by wt. coarsely ground dolomite (Microdol 4/200)	8, Exposed edges	*N.e.*	0·459	4·65	Two samples attacked, 5 slightly attacked, nibbles on 1
		8, Exposed edges	*C.l.*	0·447	4·48	Five samples attacked, 3 slightly attacked
		8, Exposed edges	*C.a.*	0·366	3·78	Seven samples slightly attacked, nibbles on 1
	As above — 47·5% by wt. fine dolomite (Microdol Extra)	8, Exposed edges	*N.e.*	0·543	4·20	Four samples attacked, 4 slightly attacked
		8, Exposed edges	*C.l.*	0·200	1·54	Six samples slightly attacked, nibbles on 2
		8, Exposed edges	*C.a.*	0·331	2·52	Seven samples slightly attacked, nibbles on 1
	As above — 47·5% by wt. micronized labradorite (Microvit)	8, Exposed edges	*N.e.*	0·309	2·50	Eight samples slightly attacked
		8, Exposed edges	*C.l.*	0·123	0·94	Four samples slightly attacked, nibbles on 4
		8, Exposed edges	*C.a.*	0·194	1·66	Six samples slightly attacked, nibbles on 2
	As above — 47·5% by wt. coarser labradorite (Aluvit 100)	8, Exposed edges	*N.e.*	0·270	2·65	Seven samples slightly attacked, extensive nibbles on 1
		8, Exposed edges	*C.l.*	0·178	1·71	One sample attacked, 6 slightly attacked, nibbles on 1
		8, Exposed edges	*C.a.*	0·210	2·03	Five samples slightly attacked, nibbles on 3
	As above — 47·5% by wt. micronized muscovite mica (Micro-Mica W)	8, Exposed edges	*N.e.*	1·620	11·15	Seven samples attacked, 1 slightly attacked
		8, Exposed edges	*C.l.*	0·945	7·12	Three samples badly attacked, 4 attacked, 1 slightly attacked
		8, Exposed edges	*C.a.*	1·667	10·55	Four samples badly attacked, 4 attacked
	As above — 47·5% by wt. talc with magnesite (Microtalc AT1)	8, Exposed edges	*N.e.*	0·431	3·85	Two samples attacked, 6 slightly attacked
		8, Exposed edges	*C.l.*	0·123	0·93	Two samples slightly attacked, nibbles on 6
		8, Exposed edges	*C.a.*	0·195	1·49	Five samples slightly attacked, nibbles on 3
	As above — 47·5% by wt. fine talc with magnesite (Microtalc AT1 Extra)	8, Exposed edges	*N.e.*	0·485	3·85	Two samples attacked, 6 slightly attacked
		8, Exposed edges	*C.l.*	0·135	1·04	Four samples slightly attacked, nibbles on 4
		8, Exposed edges	*C.a.*	0·250	1·82	Seven samples slightly attacked, nibbles on 1
	As above — 47·5% by wt. fine talc with magnesite (Microtalc 1T Extra)	8, Exposed edges	*N.e.*	0·310	10·50	Seven samples attacked, 1 slightly attacked
		8, Exposed edges	*C.l.*	0·402	3·29	Two samples badly attacked, 2 attacked, 2 slightly attacked, nibbles on 2
		8, Exposed edges	*C.a.*	1·221	10·40	One sample badly attacked, 6 attacked, 1 slightly attacked
	As above — 47·5% by wt. calcined china clay (Polyfil 40 Clay)	8, Exposed edges	*N.e.*	0·185	1·55	Six samples slightly attacked, extensive nibbles on 2
		8, Exposed edges	*C.l.*	0·042	0·35	Eight samples with nibbles only
		8, Exposed edges	*C.a.*	0·135	1·24	Seven samples slightly attacked, nibbles on 1

	As above + 47·5% by wt. ground whiting	8, Exposed edges	*N.e.*	0·563	4·20	Five samples attacked, 3 slightly attacked
		8, Exposed edges	*C.l.*	0·314	2·67	One sample attacked, 7 slightly attacked
		8, Exposed edges	*C.a.*	0·439	3·39	Five samples attacked, 2 slightly attacked, nibbles on 1
	As above + 47·5% by wt. ground limestone	8, Exposed edges	*N.e.*	0·644	5·20	Seven samples attacked, 1 slightly attacked
		8, Exposed edges	*C.l.*	0·375	3·00	Four samples attacked, 3 slightly attacked, nibbles on 1
		8, Exposed edges	*C.a.*	0·445	3·63	Seven samples attacked, 1 slightly attacked
4	Corvic D65/8 PVC polymer, D.O.P.-plasticized at 30·5 parts/100 parts total mix; density 1·31, B.S.H. at 20°C 88, cable 0·125 in. diam.	8, Uncapped	*N.e.*	0·053	0·50	Three samples attacked, 5 sound
		8, Uncapped	*C.l.*	0·033	0·35	One sample destroyed (core exposed), 1 slightly attacked, nibbles on 1
	As above + 5% by vol. fine silica, S3E; density 1·42, B.S.H. at 20°C 90	8, Uncapped	*N.e.*	0·015	0·15	Areas of nibbles on 4 samples
		8, Uncapped	*C.l.*	0·030	0·30	Two samples badly attacked (at ends), 2 slightly attacked, nibbles on 4
	As above + 10% by vol. fine silica, S3E; density 1·42, B.S.H. at 20°C 92	8, Uncapped	*N.e.*	0·015	0·15	Areas of nibbling on 4 samples
		8, Uncapped	*C.l.*	0·030	0·30	One sample destroyed (core exposed), 2 slightly attacked, nibbles on 3
5	Corvic D65/8 PVC polymer, D.O.P.-plasticized at 30·5 parts/100 parts total mix; density 1·31, B.S.H. at 20°C 88, sheet 0·0625 in. thick	7, Exposed edges	*N.e.*	0·214	3·30	One sample attacked, 5 slightly attacked, extensive nibbles on 1
		8, Exposed edges	*C.l.*	0·448	5·45	Three samples attacked, 5 slightly attacked
	As above + 5% by vol. fine silica, S3E; density 1·38, B.S.H. at 20°C 91	8, Exposed edges	*N.e.*	0·049	0·70	Two samples slightly attacked, nibbles (some extensive) on 6
		8, Exposed edges	*C.l.*	0·119	1·45	Three samples attacked, 5 slightly attacked
	As above + 10% by vol. fine silica, S3E; density 1·43, B.S.H. at 20°C 92	7, Exposed edges	*N.e.*	0·055	0·60	Seven samples slightly attacked
		8, Exposed edges	*C.l.*	0·092	1·00	One sample attacked, 6 slightly attacked, nibbles on 1
	As above + 5% by vol. medium silica, 400 WQ; density 1·37, B.S.H. at 20°C 90	7, Exposed edges	*N.e.*	0·069	0·80	Nibbles on edges of all 7 samples (some extensive)
		8, Exposed edges	*C.l.*	0·271	3·20	Four samples slightly attacked, nibbles on 4
	As above + 10% by vol. medium silica, 400 WQ; density 1·42, B.S.H. at 20°C 92	7, Exposed edges	*N.e.*	0·167	2·35	Nibbles on all 7 samples (extensive on 5)
		8, Exposed edges	*C.l.*	0·207	2·45	Two samples slightly attacked, nibbles on 6
	As above + 5% by vol. coarse silica, S3BC; density 1·37, B.S.H. at 20°C 89	8, Exposed edges	*N.e.*	0·172	2·05	One sample attacked, 5 slightly attacked, nibbles on 2
		8, Exposed edges	*C.l.*	0·346	4·30	Two samples attacked, 6 slightly attacked
	As above + 10% by vol. coarse silica, S3BC; density 1·43, B.S.H. at 20°C 91	8, Exposed edges	*N.e.*	0·129	1·55	Seven samples slightly attacked, nibbles on 1
		8, Exposed edges	*C.l.*	0·287	3·60	Eight samples slightly attacked
		Polyethylene				
6	Polythene grade 2, untreated (0·125-in.-diam. rod)	8, Uncapped ends	*N.e.*	0·005	0·18	Few nibbles on ends of samples
		8, Uncapped ends	*C.l.*	0·015	0·45	Slight attack on ends of 4 samples, nibbles on 4
	As above + 0·1% silica	8, Uncapped ends	*N.e.*	0·008	0·30	Nibbles at ends and along samples
		8, Uncapped ends	*C.l.*	0·029	1·05	Nibbles along full length of all samples
	As above + 1% silica	8, Uncapped ends	*N.e.*	0·008	0·24	Nibbles at ends and along samples
		8, Uncapped ends	*C.l.*	0·047	1·60	Slight attack on ends of 4 samples, extensive nibbles on all
	Polythene, grade 0·3, untreated (0·156-in.-diam. rod)	8, Uncapped ends	*N.e.*	0·012	0·43	Slight attack on ends of 4 samples, nibbles on 4
		8, Uncapped ends	*C.l.*	0·040	1·40	Slight attack on ends of 4 samples, extensive nibbles on all
	As above + 0·1% silica	8, Uncapped ends	*N.e.*	0·019	0·43	Slight attack on ends of 2 samples, nibbles on 6
		8, Uncapped ends	*C.l.*	0·015	0·33	Nibbles on ends of all samples
	As above + 1% silica	8, Uncapped ends	*N.e.*	0·014	0·43	Slight attack on ends of 4 samples, nibbles on 4
		8, Uncapped ends	*C.l.*	0·022	0·63	Attack on end of 1 sample, nibbles on ends of 7

TABLE 7 (*Continued*)

Test No.	Details of Sample	No. and Type of Samples	Test Sp.	Amt. (g)	Eaten (%)	Remarks
		Polyethylene (Continued)				
7	DFDL–6015 polyethylene, 0·0625-in.-thick sheet; density 0·919, melt index 0·3, with 2·5% carbon black, untreated	8, Strips (exposed edges)	*N.e.*	0·010	0·15	Isolated nibbles on edges of all 8 samples
		8, Strips (exposed edges)	*C.l.*	0·224	3·35	Three samples attacked, 4 slightly attacked, nibbles on 1
		8, Strips (exposed edges)	*C.a.*	0·431	6·63	Three samples attacked, 5 slightly attacked
		8, Strips (masked edges)	*N.e.*	*	*	No visible attack
		8, Strips (masked edges)	*C.a.*	0·133	1·42	One sample attacked, nibbles on 3
	As above — 1% ultra-fine silica (average particle size 2-4 μ)	8, Strips (exposed edges)	*N.e.*	0·010	0·16	Isolated edge nibbles on 7 samples
		8, Strips (exposed edges)	*C.l.*	0·122	1·85	Six samples slightly attacked, nibbles on 2
		8, Strips (exposed edges)	*C.a.*	0·342	5·28	One sample attacked, 7 slightly attacked
		8, Strips (masked edges)	*N.e.*	*	*	No visible attack
		8, Strips (masked edges)	*C.a.*	0·194	2·15	Three samples slightly attacked, nibbles on 1
	As above — 2·5% ultra-fine silica	8, Strips (exposed edges)	*N.e.*	0·009	0·13	Isolated edge nibbles on 7 samples
		8, Strips (exposed edges)	*C.l.*	0·10	1·50	Five samples slightly attacked, nibbles on 3
		8, Strips (exposed edges)	*C.a.*	0·306	4·60	Two samples attacked, 6 slightly attacked
		8, Strips (masked edges)	*N.e.*	*	*	No visible attack
		8, Strips (masked edges)	*C.a.*	0·141	1·50	Two samples slightly attacked
	As above — 5% ultra-fine silica	8, Strips (exposed edges)	*N.e.*	0·005	0·07	Edge nibbles on all 8 samples
		8, Strips (exposed edges)	*C.l.*	0·158	2·40	Eight samples slightly attacked
		8, Strips (exposed edges)	*C.a.*	0·322	4·80	One sample attacked, 7 slightly attacked
		8, Strips (masked edges)	*N.e.*	*	*	No visible attack
		8, Strips (masked edges)	*C.a.*	*	*	No visible attack

* Small weight loss recorded but not confirmed by visual appearance of sample.

Although the intrinsic hardness of the dusts varied considerably, the British Standard Hardness of the resultant products was fairly uniform, ranging from 88 to 91.

The samples were exposed to the attack of *C. lacteus* and statistical analysis of the percentages eaten shows that the termite resistance of polyvinyl chloride is significantly improved by the addition of the following materials, listed in order of decreasing effectiveness: hard silica, zircon flour, diatomaceous earth, barytes, soft silica, feldspar, calcite, powdered glass yarn, water-ground whiting, activated whiting, fine-particle silica, talc. The effects of these fillers were so striking, particularly of the first three which reduced damage 66–80% below the untreated level, that further investigation was warranted (Fig. 5).

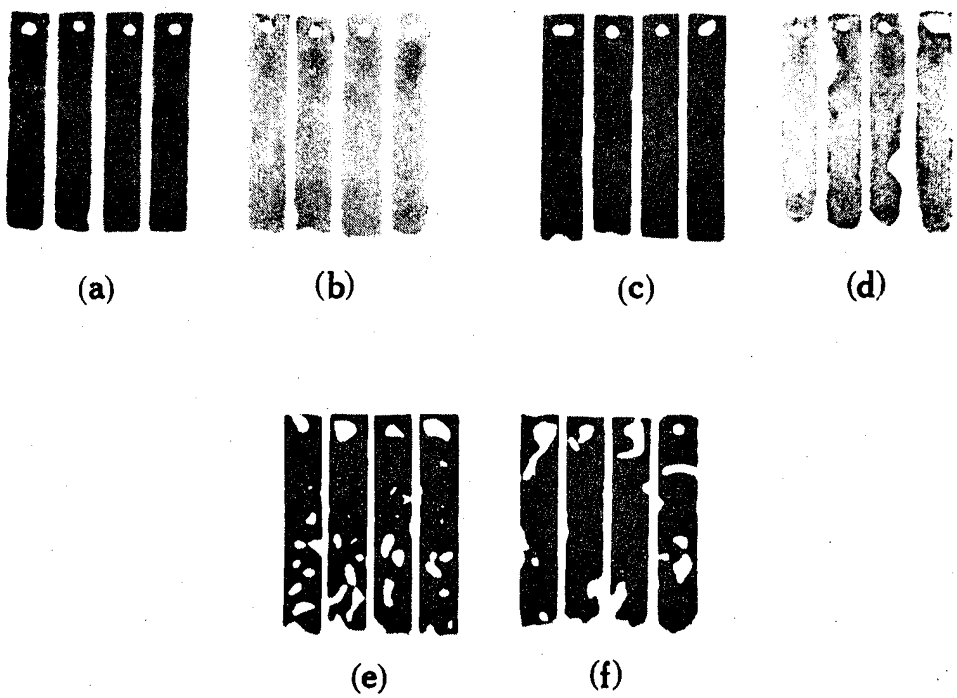


Fig. 5.—Samples of polyvinyl chloride containing various mineral fillers after exposure to attack by *Coptotermes lacteus* in laboratory colonies. (*a*) Hard silica, 5%; (*b*) zircon flour, 5%; (*c*) diatomaceous earth; (*d*) untreated; (*e*) Micafine P, 5%; (*f*) hard clay, 5%.

In Test No. 2 (Table 7), four fillers covering the range from least to most effective in the previous test were re-checked using a different base resin with lower plasticizer level, and the effect of varying the percentage content of filler was also studied. The results confirm that both clay and whiting fillers have little or no value for termite protection and even though improving the hardness might in fact make the end product more susceptible. However, silica and barytes fillers reduce susceptibility quite significantly, and this reduction is positively correlated with the level of addition.

In Test No. 3 (Table 7), a third type of base resin with a moderately high level of mixed plasticizers was used to test a number of different fillers. The level of addition

of fillers was constant at 47·5% by weight and as the specific gravity of the minerals involved ranged from 2·7 to 3·0 this represents a percentage by volume of approximately 16–17·5. Although no untreated control samples were available, the results demonstrate the wide variation in effectiveness of different fillers. The most effective material was calcined china clay and as this result contrasts strongly with those obtained for clay fillers in Tests 1 and 2 it is possible that the improvement is associated with calcining. There is some suggestion from the results with labradorite, dolomite, and talc plus magnesite samples that the particle-size range of fillers influences their performance, but particle-size analyses are needed to confirm this.

In Tests Nos. 4 and 5 (Table 7) the same base resin and plasticizer content were processed into sheet form and cable sheath for further tests of the effects of adding silica filler. Two levels of addition were studied, viz. 5% and 10% by volume, and three grades of silica were used as additives. Details of the particle-size distribution of the silicas are given in Table 8.

TABLE 8

PARTICLE-SIZE DISTRIBUTION OF THREE SILICAS

Particle Size (mm)	S3E	Silica Additive (% by weight) 400 WQ	S3BC
<0·004	5·4	5·2	1·3
0·004–0·01	13·8	16·7	1·2
0·01–0·04	24·2	47·1	0·9
>0·04	56·6	31·0	96·6

The untreated sheet material was much more susceptible to attack by both species of termites than was the cable sheath. This is presumably a matter of geometry, in that the sheet material presents many more edges on which the termites can obtain the necessary purchase with their mandibles.

The addition of fine silica to the cable sheath had little effect on its resistance to attack by *C. lacteus*, but both levels of addition reduced the amount of attack by *N. exitiosus* by about two-thirds. All grades of silica brought about a marked improvement in the termite resistance of the sheet material to both species of termites but there was no constant relationship between increased resistance and increased level of filler. The fine silica (Grade S3E) was superior to the two other grades in reducing attack but this cannot be explained logically on the basis of particle-size distribution.

In view of the promising results obtained with silica fillers in polyvinyl chloride, and as this mineral appeared to be among the cheapest and most readily available, two tests were made with silica as a filler in polyethylene. In the first of these (Test No. 6, Table 7), silica was added at two levels to polyethylenes of different melt flow index extruded in rod form. There was no regular pattern in the results but it is evident that no worth-while improvement in termite resistance was achieved.

In the second test (No. 7, Table 7), in which low-density polyethylene was processed in sheet form with three different levels of ultra-fine silica, even the highest level of addition (5% by volume) resulted in only a slight improvement in termite resistance.

This series of tests on fillers shows that (i) certain minerals such as silica, zircon flour, barytes, and calcined china clay can materially improve the termite resistance of plasticized polyvinyl chloride, (ii) with silica and barytes at least, the level of resistance rises as the filler content is increased from 5 to 40% by volume, (iii) there is some evidence that fineness of particle size increases the efficiency of a particular filler, and (iv) the use of silica as a filler for polyethylene does not produce a comparable reduction in termite susceptibility to that achieved in polyvinyl chloride. The ineffectiveness of mineral fillers such as silica in polyethylene, coupled with the fact that all developmental laboratories concerned in the preparation of silica-filled samples of polyvinyl chloride or polyethylene have commented on the greatly accelerated rate of wear on extrusion dies, makes it unlikely that this method of improving the termite resistance of plastics could become commercially practicable.

IV. General Conclusions and Discussion

The following conclusions may be drawn from the various series of tests that have been described.

Plastics vary considerably in their susceptibility to termite damage but very few of the materials in common use are wholly immune to attack, and some, such as plasticized polyvinyl chloride, low-density polyethylene, polystyrene and polyurethane foams, and cellulose esters, are liable to severe damage. The consistent pattern of minimal attack, comprising a few nibbles along the edges or ends of samples, shown by all grades of nylon emphasizes the potential usefulness of this plastic in situations of high termite hazard.

The liability of a plastic to attack depends upon the species of termite involved and, in general, is lower for *N. exitiosus* than for species of *Coptotermes*, especially *C. acinaciformis*, which is the most widespread and economically important species of termite in Australia. In addition, the physical shape in which a particular plastic is presented to termites influences the severity of attack. This is borne out by the consistently higher levels of attack on samples with exposed ends or edges over those in which only flat or curved surfaces were accessible to the termites, and by the greater liability of termites to penetrate folded rather than flat plastic film.

The termite resistance of plastics, which is influenced by both physical and chemical factors, can be significantly improved by the manipulation of these factors. For example, changes in the nature and amount of plasticizer can materially improve the termite resistance of plasticized polyvinyl chloride, and a similar improvement has been effected in polyethylene through a change from low-density to high-density material, by increasing the molecular weight and lowering the melt flow index.

Thickness is an important factor in determining the termite susceptibility of plastic films or foils, but hardness appears to be more important in products such as piping and cable sheathing. The need for flexibility in cable sheathings and films, however, limits the extent to which hardness can be used to minimize termite damage and has directed attention to the possibility of termite-proofing plastics by incorporating insecticides during the manufacturing process.

Several different insecticides have been added to plastics on an experimental basis, and the most consistently successful results have been obtained with aldrin and

dieldrin. There are, however, certain aspects of the toxic hazard associated with the widespread use of plastics containing these materials which must be kept in mind if commercial production is contemplated. These include the end use of the product and the possibility of cumulative toxic effects on operatives engaged in the production or installation of insecticide-treated plastics.

The usefulness of selected non-toxic mineral fillers, which in small quantities can significantly reduce the termite susceptibility of some plastics without adversely affecting their physical properties, appears to be limited because of processing difficulties.

Finally, there are two broad aspects of the investigation which need to be placed in proper perspective.

The first is the question of the relevance of laboratory test results to performance in service, and whether field exposure tests would be more appropriate despite the considerable length of time which they require. The authors believe that the level of intensity of the termite hazard in the standard laboratory colonies, where the absence of a normal food source places the insects under severe food stress, is seldom, if ever, reached under natural conditions. Accordingly, any material that proves highly or completely resistant in these tests can reasonably be expected to perform similarly in service. On the other hand, field tests introduce the possibility of deterioration by other biological and/or physical factors and, for this reason, may give a better indication of the length of service life. However, the chemical stability of most plastics greatly reduces the significance of these factors, except possibly for some plasticized products or those containing insecticides, and even these can be catered for in laboratory tests by using artificial ageing or weathering techniques (Tests 6A and 6B in Table 6).

The second point is the extent to which these test results are applicable in Australia. It is evident from the consistently more severe attack by *C. acinaciformis*, as compared with *N. exitiosus*, that results obtained with the former species are valid for the whole of temperate Australia. The results of a limited number of tests with *M. darwiniensis* on eight different plastics were essentially the same as those obtained with *C. acinaciformis*. This similarity suggests that the possibility of significant differences in performance of a particular plastic exposed to these two species is slight, and that results obtained in tests with *C. acinaciformis* will also be applicable in tropical Australia.

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VI. References

Bailey, S. W. (1954).—Hardness of arthropod mouth parts. *Nature, Lond.* **173**, 503.

Becker, G. (1963).—Die Widerstandsfähigkeit von Kunststoffen gegen Termiten. *Materialprüfung* **5**(6), 218–32.

Becker, G. (1964).—Testing results on termite resistance of plastics. *Bull. R.I.L.E.M.* **25**, 93–7.

Colwill, D. J. (1958).—Notes on the preservation of materials. *Pestic. Abstr.* A **4**(2), 237–56.

Colwill, D. J. (1964).—Damage to transmission lines and cables by pests. *Pestic. Abstr.* A **10**(3), 393–487.

Gay, F. J., Greaves, T., Holdaway, F. G., and Wetherly, A. H. (1955).—Standard laboratory colonies of termites for evaluating the resistance of timber, timber preservatives, and other materials to termite attack. CSIRO Aust. Bull. No. 277.

Harris, W. V. (1962).—Termites in Europe. *New Scient.* **13**(278), 614–17.

Pacitti, J. (1965).—Termite attack on plastics and rubbers. *Int. Biodeterior. Bull.* **1**(2), 74–80.

Rychtera, M., and Bartakova, B. (1963).—"Tropicproofing Electrical Equipment." (Leonard Hill-SNTL: London and Prague.)

Snyder, T. E. (1955).—Termite attack on plastics and fabrics. *Pest Control* **23**(3), 48, 56.

Wolcott, G. N. (1946).—Factors in the natural resistance of woods to termite attack. *Caribbean For.* **7**(2), 121–34.

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